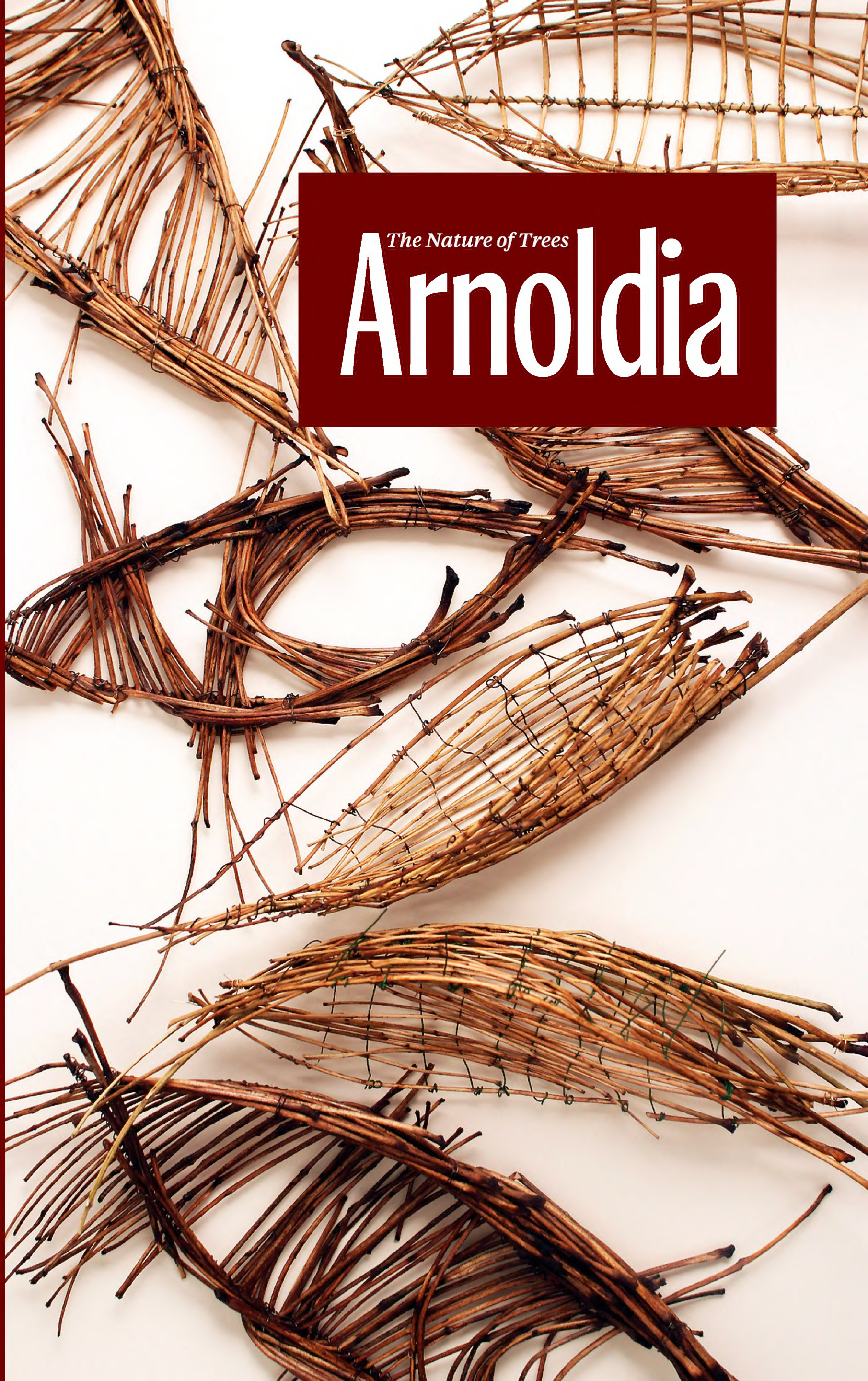
FALL 2024

The Nature of Trees

Arnoldia



Soundwalking the Arboretum

An Aztec Garden

The Idea of Wilderness

Heath and Hedge

Shedding Rain

By Matthew Battles

A few years ago, September brought a hurricane that broke apart along the whole of the east coast. As the first fronds of the storm stole inland, I lay awake in the early hours and listened to the rain sluicing down the shingles, funneling through foliage, puttering on the paving stones. There is a quiet and accessible doorway to utopia in this: all of us breathing in the dark, lying still, a vast alone-togetherness beneath the weather's comprehensive intimacies. And then I thought of the leaves in the rain, each one alive and on the brink of a fall.

Earlier that summer, we had decided to put up a shed in our backyard. It came in a kit, all the pieces precut. It was supposed to look like a log house with a slant roof in lean-to style. The wood arrived untreated, and the manufacturer recommended staining it right away to keep the wood from weathering. The rain came a few days into the project, with the doors not yet hung, the shingles still waiting to be put on the roof.

The sky brightened but the rain increased, clattering down like showers of coins through the high trees. I got out of bed to see what I could do about the unfinished shed. Halfway down the stairs, I stopped at the window looking out on our tiny side yard, where a volunteer redbud had grown into a sprightly tree fifteen, maybe twenty feet tall. I've spent a lot of time under this tree, which partly shades a hammock on the patio. On a sunny day with the canopy tiling overhead, the shadows of higher leaves project on the lower ones, making silhouettes of leaves within leaves, a dappling dance of emptiness and form. And the leaves themselves luminous, strobing, elementally green. How much light, this marvelous green light of earth, the leaves let pass! Of course, these are the wavelengths they don't use in photosynthesis. Still, whenever this leafy light is upon me, whether swinging in a hammock or walking through the landscape, it strikes me as a boon I've done nothing to earn, and never could refuse—which is to say, a kind of gift.

So it was September, and I was standing on the stairs now looking down on the leaves, and the rain was falling, and I noticed how all the leaves were cupped: the heart-shaped, entire blade of each leaf had tensed upward and inward, like when you put your hands together to catch water from a faucet, with the midrib where your pinkies touch. And here's the thing: *they weren't wet*. It was raining, raining hard, but the leaf surfaces were neatly beading the water. A leaf would bounce when the water hit it, and the water would settle into a gelid bead of

glassy reflections, plumply poised on the leaf's dry palm. As rain continued to fall, the droplets would multiply, coming together in an instant, *blip*, doubling up and doubling up and doubling up, until a single bead of water grew heavy enough, and the cupped hands of the leaf would dip, and the water would roll off like a marble; and through all this juggling of water, the leaves, like the hands of a magician, remained visibly dry.

I asked my colleague Michael Dosmann about this trick of botanical hydrophobia; he told me that it's called the "lotus effect," explaining that at nanoscopic scales a leaf's cuticle is studded with waxy asperities, microcrystalline projections, which can repel water and prevent it from wetting the leaf surface. Surprisingly, it's the roughness of this micro-topography that lets the droplets roll so smoothly, as it provides little purchase for the water to adhere. Picking up particles of dirt, the rolling waterdrops clean the leaf surface, and perhaps help to flush away pathogens, too, in a process called "self-cleaning." It seems fair to ask, though, who is cleaning whom?

Since the mid-twentieth century, the self-cleaning efficacy of the lotus effect has inspired materials scientists to develop industrial and commercial applications, resulting in a dizzying variety of paints, coatings, films, fabrics, and laser-sculpted metallic nano-surfaces. (Not all these gifts of biomimicry are benign; the formulation of per- and polyfluoroalkyl substances, also known as PFAS or "forevever chemicals" now linked to a variety of ailments, also was inspired by the lotus effect; of course, we can't blame this poisonous gift on the leaves.) But the salience of the phenomenon is ancient: in the *Bhagavad Gita*, Krishna advises Arjuna that "one who performs his duty without attachment... is unaffected by sinful action, as the lotus leaf is untouched by water."

In that September rain, I wasn't thinking about nanotechnology, or trichomes, or alkyl chains. I watched the leaves receiving the rain, rolling it into drops, and bowing, bowing here and there as they shed these gifts to fall. I thought of the prayerful hand posture practiced in many yogic and Buddhist traditions, the Anjali mudra, hands held together, fingertips to fingertips, palms gently cupped. *Anjali*: "divine offering" in Sanskrit. And I remembered how the late scholar Helen Vendler, who spent childhood days adventuring in the Arboretum, caught in her study of his *Sonnets* the way Shakespeare sometimes conjugates the verb "to love": *loving, leaving, leafless*. Vendler calls this Shakespeare's "law of nourishment and consumption."

These leaves know better than I how many droplets their offering takes.

I stayed on the stairs for some while with the leaves dipping and bowing, the loving water leaving the soon-to-be-leafless tree. And then the spell broke, and I ran outside to throw a tarp over the unfinished shed.

I am writing this now in another rainstorm, sitting on the porch next to the redbud tree, watching the rain bead and fall from the leaves. Rainfall and the song of crickets, that autumnal counterpoint. The leaves are not the same old leaves, of course, though as the season advances, neither are they new. Again, the gemlike water beads, conjoins, and slides away. Each leaf is mapped with its own constellation of droplets, more numerous than I remember, though I'm sure these leaves know better than I how many droplets their offering takes.

The shed has withstood many rains, and with many more to come, already it's streaked with the lacings of fungal growth. Years or decades from now, someone else likely will see it as a trouble to take down. Performing their duties without attachment, the leaves soon will fall, and then new leaves will come, resilient and ephemeral, to renew their gifts. I want to learn from the leaves.

MATTHEW BATTLES *is the editor of* Arnoldia.

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Autumn in the Adirondacks, where American ideas of "wilderness" were cultivated. *Photograph courtesy Edward K. Faison*

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The Nature of Trees

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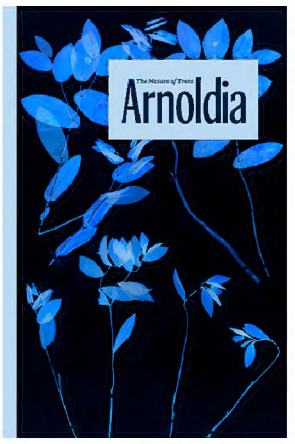

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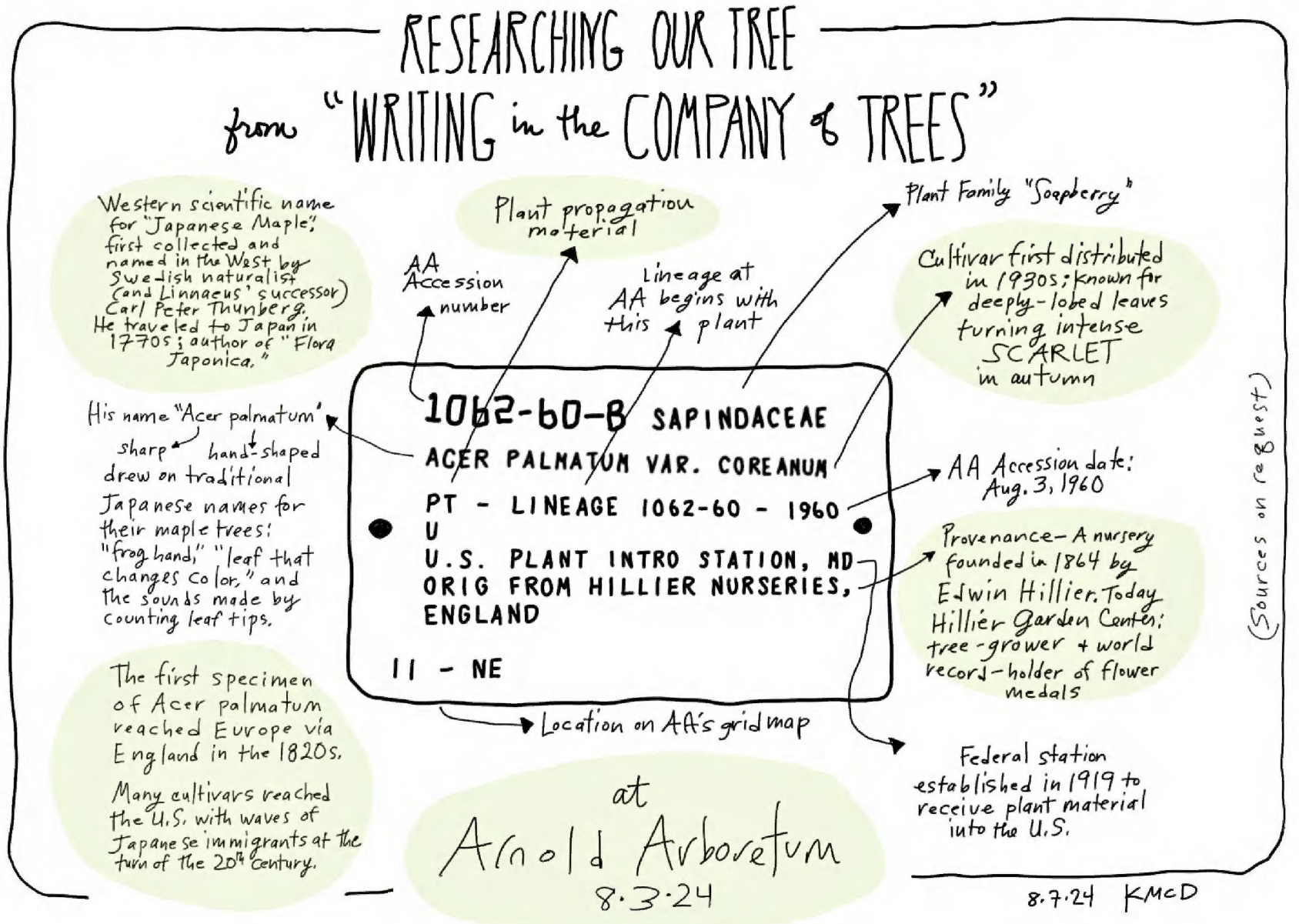
Jacek Smolicki uses microphones to tap into the Arboretum's hidden sound world, one tree at a time (see page 56). *Photograph courtesy Jacek Smolicki*

Reading Tags, Writing Trees

The last two summers, I've run a workshop in the landscape called "Writing in the Company of Trees." For a few hours, participants practice getting in touch with an Arboretum tree through writing—first encountering a chosen tree through their senses, then turning to the ecological and topographical surround, and finally delving into its story as an individual organism in our collection. The doorway to this story is the accession tag affixed to each tree, with its shorthand codes documenting the date of accession, place of origin, taxonomic, horticultural, and common names, and geographic location in the Arboretum.

In August this year, we took the workshop to the Arboretum's nationally-accredited maple collection. A few days after the program, one of the participants, Kathleen McDermott, sent me this annotation of her chosen tree's tag. "At your program," she wrote, "I re-entangled with a friend from almost 20 years ago, joyfully learning that we now have even more in common. We chose this tree together that morning, and I tasked myself with finding out more afterwards. Parsing the tag information was a great exercise.... As always with trees at (the Arboretum), one gets really deep, really quick! And, as with so many (Arboretum) trees, this one truly is a global cosmopolitan." I couldn't agree more. —Matthew Battles, editor


RESEARCHING OUR TREE
from "WRITING in the COMPANY of TREES"
Western scientific name for "Japanese Maple," first collected and named in the West by Swedish naturalist (and Linnaeus' successor) Carl Peter Thunberg. He traveled to Japan in 1770s; author of "Flora Japonica."
Plant propagation material
AA Accession number
Lineage at AA begins with this plant
Plant Family "Soapberry"
Cultivar first distributed in 1930s; known for deeply-lobed leaves turning intense SCARLET in autumn
His name "Acer palmatum" sharp hand-shaped
drew on traditional Japanese names for their maple trees: "frog hand," "leaf that changes color," and the sounds made by counting leaf tips.
1062-60-B SAPINDACEAE
ACER PALMATUM VAR. COREANUM
PT - LINEAGE 1062-60 - 1960
U
U.S. PLANT INTRO STATION, MD
ORIG FROM HILLIER NURSERIES, ENGLAND
II - NE
AA Accession date: Aug. 3, 1960
Provenance—A nursery founded in 1864 by Edwin Hillier. Today Hillier Garden Centers: tree-grower + world record-holder of flower medals
(Sources on request)
Location on AA's grid map
Federal station established in 1919 to receive plant material into the U.S.
The first specimen of Acer palmatum reached Europe via England in the 1820s.
Many cultivars reached the U.S. with waves of Japanese immigrants at the turn of the 20th century.
at
Arnold Arboretum
8.3.24
8.7.24 KMcD

KATHLEEN MCDERMOTT

Notes from the Field

To Grow with the Damage

Following the trail of turpentine through the lost longleaf pine forests of South Georgia, **Brandon O. Scott** confronts entwined histories of labor, race, and longleaf pine.

Brandon O. Scott is a doctoral candidate in the architecture department at the Massachusetts Institute of Technology.
His travel was supported by a 2023-24 ACLS/Mellon Dissertation Innovation Fellowship.

Above, as evening brought day closer to the time of night, below, my steps toward a fence brought me closer to a time bygone. Driving across the bottom of Georgia, I had stopped and parked in the narrow shoulder of the highway just outside Willacoochee, still a way aways from dinner and a motel in Tifton. Both towns are in Georgia's wiregrass region, so called because of the pervasiveness of *Aristida stricta* in the understory, numberless golden threads of it sewn into the ground, each as lambent as a filament in an incandescent bulb, so that light seems to be something that germinates—albeit a germination that must be preceded by fire, for the grass only makes viable seed when it has been burned during growing season. The wiregrass region here, just like those in the Carolinas and further down into the Gulf States, is a landscape intimate with constant destruction in service to recreating itself. My desire to understand this intimacy with regard to another plant in the region is why I was walking towards a fence, over which hung a simple post-and-lintel metal sign, the lettering timeworn but as yet obliterated—"McCranie Brothers Naval Stores 1935" —a trace of centuries past, when tar, pitch, and later rosin and turpentine—all derived from resins of the pine family — were essential for making ships seaworthy and everyday life convenient. In colonial America, it was the more northernly pitch

Illustrations by Matt Huynh

pine (*Pinus rigida*) that was first tapped, before the discovery that further south, from the bottom of Virginia down to Florida and all the way over to Texas, that longleaf pine (*P. palustris*), which seemed to cover the land "as far as the eye can see," could likewise fill barrels with its resin as heavy as hands (and hooves) could heave.

To transform resin into turpentine and rosin, you need to distill it (tar and pitch come from kilns), and so behind the sign and fence off US Route 82 is the turpentine distillery the McCranie's operated. Since it ceased production in 1942, their still has sat as it was and where it was, once the world's most productive turpentine region abounding with distilleries, today an agrarian area where the McCranie distillery is one of the last standing anywhere in the South. The McCranies left the gate open for years, a kind of roadside museum to those passing by, but since a theft not so long ago, the gates have been closed. From a distance, the still looks like a stage. One can easily imagine the various actors and actions that must be coordinated for successful production. Like cotton presses and tobacco houses, stills were structures dedicated to harnessing something from a single plant—but to get what is desired a multitude of instruments, personnel, and forces (fire, steam) must work together. Indeed, failure could be fatal, for turpentine carries flame just as well as the wiregrass amidst which it was born. Looking past the lock, I could see so many of the "props" of the lost industry on the other side; but as with every roped-off chair in a museum or vitrine-encased implement on display, sight beckons touch for a closer understanding—even when such is prohibited.

Like cotton presses and tobacco houses, stills were structures dedicated to harnessing something from a single plant.

To "trespass to land" means to enter without lawful excuse, and I suspect desire for proximity to history is no such excuse, yet at the very least perhaps I could say that as I knelt under the cross braces, my crime was more one of passion than premeditation. I felt I had to be closer—closer to touch

NATIONAL PARK SERVICE

GREEN CITIES

Connecting Communities to Growing Trees

Walking through our neighborhoods, few are likely to glance at familiar trees that line sidewalks and streets and think of the US National Park Service. The Park Service is watching over our city trees, however, and a recent study out of the USPS Pacific Southwest Research Station suggest ways to improve the urban forest across the US. "Beyond the *Golden Shovel*" engages tree planting initiatives (TPIs)—popular modes of green infrastructure spurred in part by $1 billion of federal grants to support forest resilience and climate mitigation through 2031. Researchers show that successful urban tree planting initiatives (1) ensure adequate funding for all phases; (2) cultivate place-based design; (3) engage and invest in communities; (4) follow arboricultural best practices; and (5) evaluate performance over time. Urban TPIs are significant, given that two-thirds of the human population is projected to live in urban environments by 2050. Coexistence in the built environment rests on our ability to join hands and limbs locally and nationally, turning words into action, research into practice.

the bricks that held the fire that boiled the resin in the kettle; closer to reach towards the last barrels that rolled down the ramp, but never made it to market, the turpentine long evaporated but the rosin still as good as the day it hardened. And though I did not know it was there until I turned around, I had to be closer to see a pine— its trunk hacked upward from the base to three feet high in chevron-shaped cuts that mark the years of resin channeled and extracted; the bark tries to cover over these wounds, but the physical scar of vegetal trauma, no less than the inward kinds of historical memory, never fully heal. This pine has outlived the industry and nearly all who worked in it, but even so, it must always stand facing the best-preserved remnant of the industry that consumed it, bearing witness in a more-than-just-imagined way.

In the National Register of Historic Places nomination form for the McCranie Brother's Still, the preparer observed that the structure is quite similar to distilleries constructed in North Carolina around 1830, a whole century before the McCranies built their distillery in 1936—a duration signifying the technological stasis of the industry. In making its way from North Carolina down to Georgia, however, the industry itself did move across space, even if the tech did not move in time. Turpentining was practiced and refined in North Carolina for nearly a century until, finally, there were not enough pines left in the state for plantations to profit. In the years after the Civil War, the industry shifted further south, and it wasn't just the architecture and tools that came from North Carolina. As Robert Outland III put it in his account of the industry, "the typical turpentine laborer in Wiregrass Georgia in the 1870s was a young, single, illiterate, black man from North Carolina." The same could be said for Florida and, to an extent, for Alabama and Mississippi as well. Whole plantations moved from the state with the expertise of slaves and later freedmen to do what they had done to the forests there, owners working their men as hard and fast as their trees, for more always seemed to be got somewhere. As a young, single, albeit literate black man from North Carolina a century and a half later, the more I lingered in these forests further south, the more I felt that, instead of trespassing into land, the land was trespassing into me, and whether I wanted to or not, I was suddenly on a living-history stage presided over by longleaf pine.

I was suddenly on a living history stage presided over by longleaf pine.

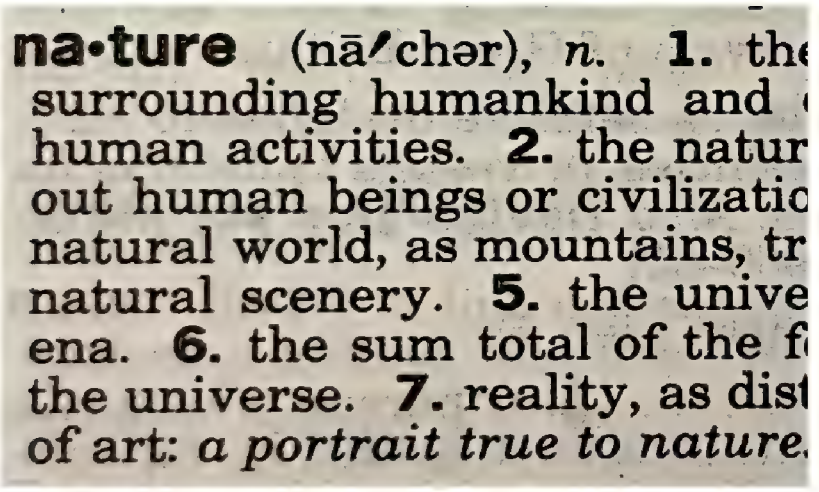
In Tifton, I missed the annual still-firing day at the Georgia Museum of Agriculture, but I did buy a bottle of the turpentine made there. The scent of pine growing thicker through the day was due not to traveling further into the stands of longleaf, but to my driving with a tilted bottled of volatile sprits in the full sun of June. Left for the rest of my trip with the indelible smell of turpentine in my clothes and throat, I had to imagine how long the distillery must have lingered in the lungs of its operators even after its closure like a bundle of pine straw bound in the chest—the work gone, but the labor of dealing with your labor unending.

Later, while in conversation with the manager of the Southern Forest World Center in Waycross, she gestured toward a photograph in their naval stores gallery. It was of a black prisoner, a convict leased to a turpentine operation—"I don't mean to make things racial," she began, "and I have never owned or leased another human being, and I don't feel like it is probably right, but it is a shame that that messed up such honest work." In the frankness with which the industry left its mark on the pines and on the people who worked the pines, I can see the "honesty" of this industry; otherwise, as far as I know, turpentining was never

without some form of unfree labor. But I did not press the point.

She told me that if I wanted to learn more about naval stores in the area, I should go next door to the local heritage center. That day there just happened to be a festival celebrating local history and tradition—indeed cannon and rifle fire boomed as I approached. Perhaps I should have heard in those shots a warning that by celebration of local history, it meant specifically the kind before 1865. I stepped into the pine-shaded venue where there were probably more "stars and bars" flying than there were at Fort Sumpter. Around a corner, sitting on the ground, I passed a group of "Seminole Indians," and further down the path toward where I was told the naval stores expert should be, I saw a soldier dressed in full rebel grays, and suddenly I felt I could not approach him, so I walked an awkward loop and sat in the old train station—it like so many stations in the south largely funded by desire to get turpentine to coastal markets.

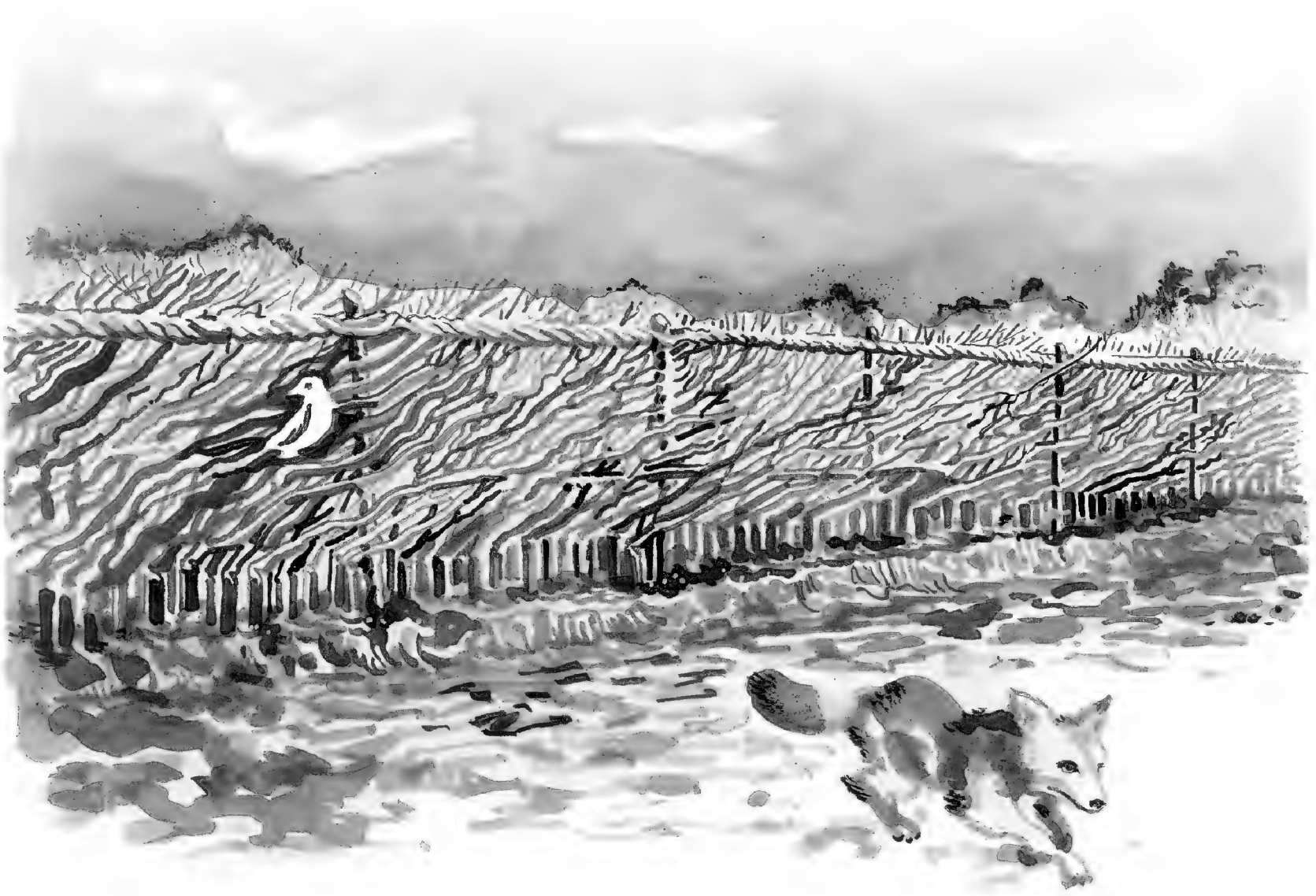
In that moment I realized how reenactment does not just reproduce gestures, accoutrements, and period speak, but that it resuscitates something that resists being timebound in the first place, something that lies waiting to come out again, as it did before, but not exactly how it did it before. The pines perhaps participate in such reenactment even better than people. At another tree last tapped likely over a century ago, I traced its scars from the ground where the first cut was made up to a height that stopped at my face. From just below the bark above the last scar, summer sunlight got caught in a fresh bead of resin that started falling down the tree's face like a slow tear for longleaf history and the centuries of extraction this entail. But it was only "like a tear" for the drop carried another lesson beyond metaphor about the persistence of past landscapes. Pines secrete resin as response to injury and though injury means damage it also means the possibility to address the damage, turn it into a scar, and, like the tree, to grow not past damage but with it.


na·ture (nā′chər), *n.* **1.** the surrounding humankind and human activities. **2.** the natur out human beings or civilizatio natural world, as mountains, tr natural scenery. **5.** the unive ena. **6.** the sum total of the f the universe. **7.** reality, as dist of art: *a portrait true to nature.*

LOST WORDS

(Re)defining nature to include humans

A July 2024 article in *The Guardian* unpacked recent lexicographic disputes regarding the definition of nature, revealing a striking linguistic rupture. In "What is 'nature'? Dictionaries urged to include humans in definition," Damien Gayle writes: "[c]urrently all English dictionaries define nature as an entity separate from and opposed to humans and human creations,"—including the *Oxford English Dictionary*, which defines nature as "the phenomenon of the physical world collectively; especially plants, animals and other features and products of the earth itself, as opposed to humans and human creations." Such definitions—which assert opposition between humans and nature—are a cause of concern across environmental and ecological spheres, where the inseparability between humans and nature is not only obvious and scientifically accurate, but essential to how we understand ourselves as humans, and thus our relationships and ethical responsibilities in the Anthropocene. Perhaps contrary to what one may think, dictionaries do not necessarily determine what words mean; instead, lexicographers examine how people use language, and arrive at definitions accordingly. Thus, urging dictionaries to include humans in the definition of nature is not so much a box to check, but rather a dialogue for us all to engage in.



In Heath and Hedge, the Human Touch

Adam Banks explores the roots of ecological horticulture in the United Kingdom, where biodiverse habitats have evolved in the embrace of human care.

Adam Banks (Hunnewell Intern Class '21) is an assistant seasonal horticulturist at Chanticleer in Wayne, Pennsylvania, and was a Garden Club of America-Royal Horticultural Society Interchange Fellow for 2023-24.

On a cool September day in Surrey, United Kingdom, I stood looking over a heathland as the autumn sun sank in the sky. The green heathland floor of ferns (*Pteridium aquilinum*) and fescue (*Festuca ovina*) was peppered with the pink and purple blooms of heathers (*Calluna vulgaris, Erica tetralix* and *E. cinerea*). Looming above these were prickly cloudlike forms of gorse (*Ulex europeaus*), whose yellow flowers glowed against the dimming sky. The few trees that had climbed above six feet were almost entirely silver birch (*Betula pendula*) and Scots pine (*Pinus sylvestris*). Eurasian chaffinches and wood pigeons flitted in and out of the shrub layer in the diminishing light, announcing their arrivals and departures with coos and chirps. As natural as this quiet evening scene appeared, the ecosystem at hand was absolutely anthropogenic. The history of heathlands in the United Kingdom is a long one of human expansion and unexpected mutualism.

The story of heathlands stems greatly from their characteristically acidic soils. Low pH soils are often a limiting factor for plant growth, often inhospitable to the point where many plants cannot tolerate them. Landscapes of this acidity in the

Illustration by Matt Huynh

United Kingdom often have a very low yield rate when used for agriculture or timber production. Recognizing this, bronze age humans (beginning roughly 3000 years ago) in what is now the UK sought a new approach to harness these areas for their own interests: they began clearing what trees existed in order to create grazing land for their livestock. Over time, continuous grazing pressure began to alter the species makeup of these areas, as only the species which were able to deal with considerable levels of disturbance, or biologically defend themselves from predation, were able to thrive. Prime examples of these are heathers (*Calluna* and *Erica*), which regenerate readily upon damage, and gorse (*Ulex europeus*), which falls short of appetizing with its needle-sharp spines. Tree saplings were most often nibbled before they could reach maturity, continuously keeping the canopy level clear. This same process occurred throughout many parts of the country, ushering a new type of ecosystem which was dependent on human intervention.

As with any given ecosystem, a unique floral composition created niches for a variety of fauna. Over centuries, millennia in many cases, many species of birds, reptiles, mammals, and invertebrates have developed a deep reliance on heathland ecosystems. For instance, all six species of reptiles in the UK can be found in heathland ecosystems, according to the UK's Wildlife Trusts.

Many species of birds, reptiles, mammals, and invertebrates have developed a deep reliance on heathland ecosystems.

Fascinatingly, while most ecosystem types are damaged by intense human intervention, as we can easily observe in the case of forests felled for farmland or rivers polluted by chemicals, heathlands thrive on anthropogenic disturbance. After losing much of its economic utility, heathland today is broadly threatened. In the absence of pressure from herbivores, other flora slowly began to encroach on heathlands, and the established biotic processes which upheld the ecosystem faltered. According to Wildlife Trusts, only 20 percent of lowland heaths have survived the past 200 years.

Today, however, many have looked back and recognized heathlands as valuable environmental assets. Town governments are taking initiative to preserve their heathlands to maintain what biodiversity still exists. I have observed this in the form of cattle that have been released in heathland to continuously graze. While no longer truly required for agricultural purposes, these herbivores have the important responsibility of eating to preserve, whether they know it or not. The presence of these ungulates not only perpetuates numerous niches for flora and fauna, but continues an old British tradition of landscape management.

The United Kingdom is abundant in such habitat stewardship traditions. For millennia, the peoples of this island nation have been generating ideas to maximize resource yields and to regulate natural variables. Confined to an area roughly equal to the state of Oregon (or 2.5% of the total landmass of the United States), the United Kingdom has a remarkable spectrum of climatic, geologic, and floral systems. In tandem with these natural conditions, human culture varies greatly throughout the country. This combination of environmental and cultural variability contributes to a substantial range in landscape management techniques.

Perhaps one of the most iconic examples of this is the art of hedge laying. Before traveling to the UK, I envisioned hedges solely as a linear planting of a single species of shapeable shrub, often selected for their dependably fastigiate form in order to form a uniform aesthetic screen. Laid hedges are quite different from this, however. In essence, a laid hedge is a living wall of regenerative woody plants not bound to floral homogeneity. In their flourishing diversity, they are sturdy, practical creations, specially maintained to last.

Hedgelaying in the UK stems from necessity, when farmers needed a pragmatic way to keep their livestock corralled and demarcate property lines. Limited lumber and damp conditions were possible factors that contributed to the concept of creating barriers utilizing plants. Centuries ago, peoples of the United Kingdom developed a technique of first planting a living wall of woody plants, and then managing its

growth. The basic objectives of hedgelaying are to create a formidable obstacle which will hold in livestock, remain consistently vigorous, and generate habitat for flora and fauna alike.

The process of hedgelaying is one of disturbance, stressing and arranging plants to encourage denser, more productive growth. This can be done when the plants in the hedge have reached an age when they are beginning to lose their vigor or when they have grown leggy. Consistent in the practice is the severance of the lower stem most of the way through, often to 80 or 90 percent. This uncut portion (10 or 20 percent) remains, functioning as a hinge to lay the stem at an angle, as well as a persistent cambial connection to the roots, keeping the stem alive. Still connected to the roots by that small hinge, this laid stem, known as a "pleacher," will now push out new growth straight upwards from its nodes. The result is a flush of thick, vigorous shoots which rejuvenate the health and form of the hedge. For many plants, this process will often increase flowering and fruiting, in line with the same principles we use for apple pruning in the northeastern United States.

As stated above, however, there are a variety of regional styles, nine of which are recognized by the National Hedgelaying Society. Many of these styles involve weaving pleachers through stakes to give some framework to the hedge and sometimes young willow branches to hold these together. The style I got to try this past winter was that of Devon, which involved creating an elevated hedge upon a mound of soil, a further deterrent to otherwise-escapee livestock. The pleachers are held prone against the earth with hazel crooks (natural joints of hazel, *Corylus avellana,* cut to create a large pin). Having the pleacher lie against the soil sometimes results in the layering of the plant, creating even heartier growth.

Traditionally, the hedgelayer uses a billhook, a thick metal blade resembling something between a cleaver and sickle, specific to the UK for this task. The hedgelayer cuts into the woody stem at an angle and then wiggles the billhook downward with the grain to achieve the desired hinge. To add to regional differences, each county in the nation traditionally had their own billhook blade style, some more dense and blocky, others more elegant and curved.

While some hedges may primarily use a single, malleable species, like hazel (*Corylus avellana*), often many are taxa used to create a hedge. Any woody plant species that regenerates under stress and is strong enough to hold up against livestock is a candidate. Many hedges, like the one I had the opportunity to lay, are a beautiful mixture of United Kingdom native woody plants, leading to an even greater diversity of associated flora and fauna. Species that I encountered included hazel, field maple (*Acer campestre*), common hawthorn (*Crataegus monogyna*), bird cherry (*Prunus padus*), blackthorn (*Prunus spinosa*), holly (*Ilex aquifolium*), and spindle (*Euonymus europaeus*). When working with a range of species, I quickly found that different

WELL SAID

"We can find considerable joy and satisfaction in the wildness in our own backyards."

Edward K. Faison in "Wilderness in Ecology and History," page 20.

plants pose separate challenges in the hedgelaying process. Hazel is a great example of a species which is easier to cut into with a billhook, and one can predict the point at which they will bend or snap. Spindle, on the other hand, is made of harder wood, and is much more willing to fracture as you maneuver your billhook in the groove you have cut to achieve the desired angle. And one cannot forget the spiteful blackthorn, whose thorn tips break off in your skin and leave you with the laborious task of removing them.

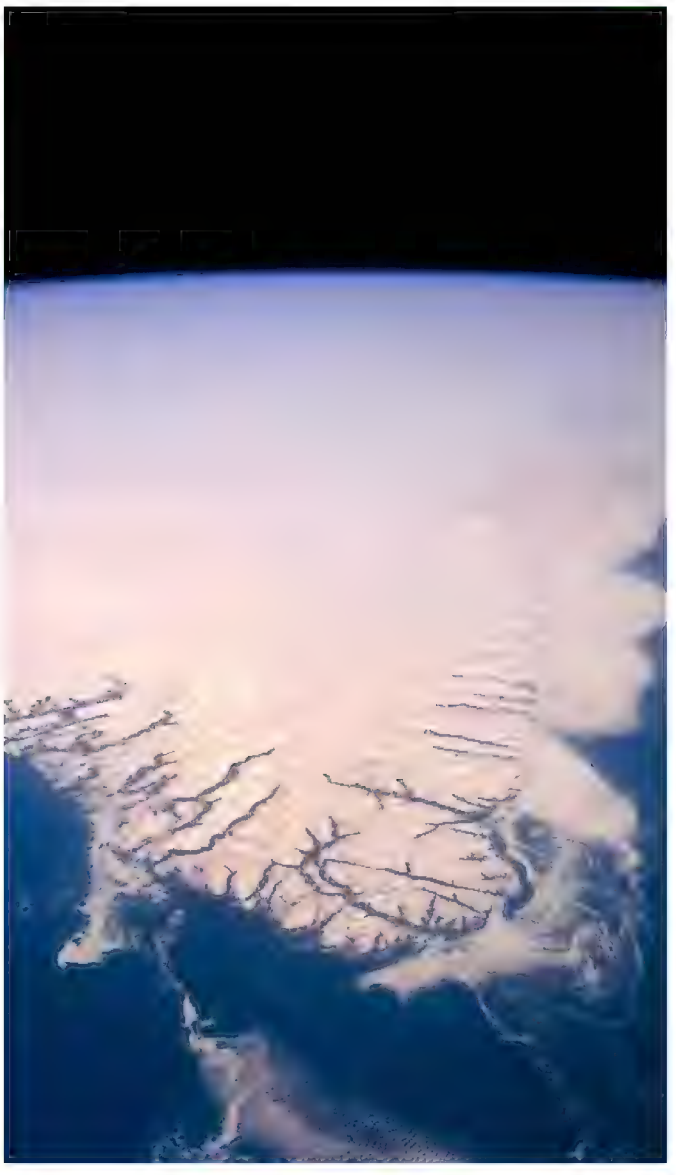
In the laying of a hedge, one essentially creates a linear forest, with protected spaces for rodents to make their dens, branches in which birds can nest, niches for invertebrate activity, and sheltered pockets for smaller animals. While unpassable for bovine residents, smaller mammals such as foxes or even badgers can often clear the small passageways. In addition, depending on the species makeup of the hedge, it can offer great multiseason feeding opportunities for frugivorous fauna. Studies have shown that these walls of green are hotspots of biodiversity. Due to the history of forest clearing and fragmentation within the UK, the government is recognizing their substantial conservation potential. There are now financial incentives in place for landowners who lay hedges on their land, which has reinvigorated this art.

Industrialization in the United Kingdom came at a hefty cost in respect to biodiversity, as well as in range of traditional landscape management techniques. However, efforts on the individual and community level are certainly being made to repair these environmental and cultural holes in the hull of the nation. Sheep and cows are now returning to lands once overgrown, keen young farmers are picking up billhooks and scythes, and governmental officials are pushing for agricultural support, all doing their part to reforge an ancient relationship with the land.

DEEP TIME

Finding the future under Greenland's ice

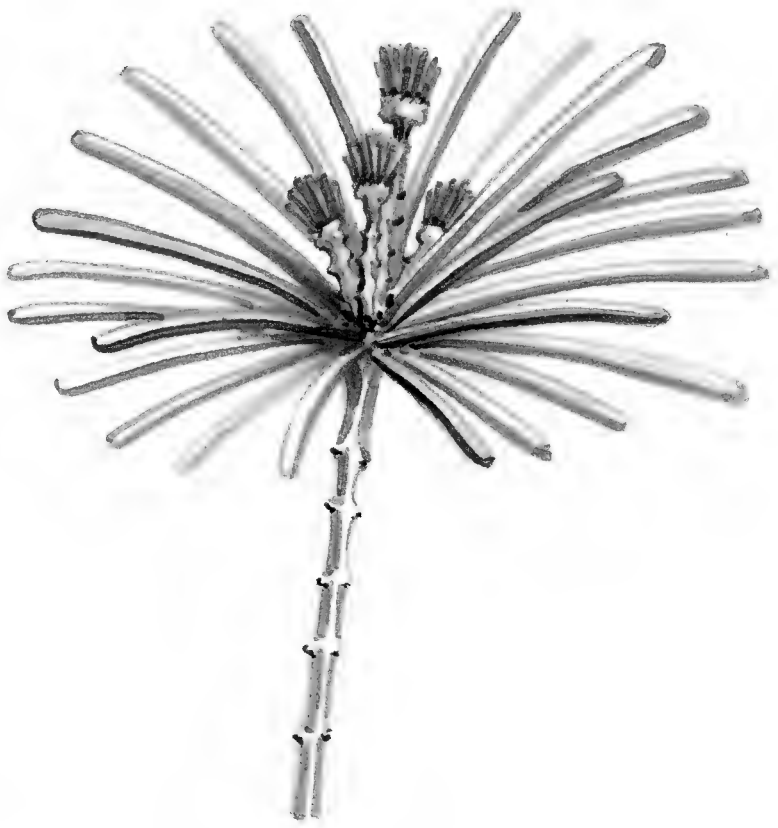
To the public eye, visual evidence of deglaciation commonly includes time-lapse videos of glacial retreat and heart-wrenching images of stranded polar bears. To scientists, however, recent scanning-electron microscopy of glacial till beneath the middle of the Greenland Ice Sheet enhances our understanding of the history of deglaciation in the arctic biosphere. As published in *Proceedings of the National Academy of Sciences,* researchers analyzed a 1993 collection of glacial till from beneath 3km of ice in Summit, Greenland, where they found a bud scale of *Salix* sp. (willow), megaspores of *Selaginella rupestris* (rock spike-moss), a *Papaver* sect. *Scapiflora* (poppy) seed, sclerotia of the soil fungus *Cenococcum geophilum,* pieces of angiosperm wood, and insect body parts—suggesting that much of Greenland was open tundra during the Pleistocene, even where the ice sheet today is at its thickest. The subglacial archival discovery enhances knowledge about Greenland's geologic landscape and will inform future research regarding global sea level rise.



USGS

Around the World to Find the Whorled "Pine"

Anthony S. Aiello returns to a challenging mountain site to find a horticultural favorite thriving in the wild.



After a full morning and afternoon of strenuous uphill hiking through a continuous heavy rain, we finally reached one of our top target species, *Sciadopitys verticillata,* the Japanese umbrella pine. At this point in mid-afternoon, we were thoroughly drenched, with only a few securely wrapped items that had stayed dry, and we all felt as though we had gone swimming in our field gear. It was September 2018 and along with colleagues Steve Schneider and Michael Dosmann (Arnold Arboretum), Todd Rounsaville (Polly Hill Arboretum), and Mineaki Aizawa and Tatsuhiko Shibano (Utsunomiya University) we were exploring the Hokkaido University Research Forest in the Kii peninsula of Wakayama Prefecture, in the southerly part of the island of Honshu in Japan. Damage from Typhoon Cimaron in the previous month made access to the site challenging due to washouts and fallen trees, adding a good mile or two to our hike to reach the more diverse forest. We slogged up the mountain along countless slick stone steps, wearing requisite Wellington boots and hard hats, and stopping to make a number of worthwhile collections. These included *Hydrangea sikokiana, Pseudotsuga japonica, Stewartia monadelpha* (collected from massive trees with exquisite copper-colored bark), and a trio of *Enkianthus: E. sikokianus, E. cernuus* f. *rubens,* and *E. nudipes.* The day also included attempting to somehow take field notes on soggy write-in-the-rain paper and eating bento boxes that had been packed for us in the morning, with steam rising from the still-warm rice. So, after several hours of keeping brave faces, we were excited to reach the pinnacle of the day: a population of umbrella pine.

Discomfort aside, we all realized that this was a special moment, and that we might not have the chance to return to this botanically rich forest or see *Sciaptopitys* again in the wild. Despite being too wet and exasperated to spend much time observing the site, and as eager as we were to head back down the mountain, we gathered ourselves and excitedly collected some cones; we then picked our way down the numerous flights of slippery steps and back towards our lodgings, with our Wellies not providing much support or traction. Maybe it was the rain that clouded our judgement or maybe it was inexperience, but what we hadn't realized was that umbrella-pine cones take two years to mature, and we had gathered one-year-old cones! We were relieved to finally be off of the mountain and reach the road, and despite our desire to dry off, we stopped for a fortuitous collection of *Daphniphyllum macropodum* near our cars: the typhoon had broken a large branch from the 15-meter-tall tree—otherwise we would not have been able to reach the fruit.

Luckily, we were able to return to the same location exactly one year later in September 2019, and this time we were met with bright, clear skies—although still with the daunting climb up the mountain. The road into the forest had been repaired, so we saved a mile or so of walking. It was mostly the same group, this time with Ian Jochems (Polly Hill Arboretum) and minus Michael

Anthony S. Aiello is the associate director for conservation, plant breeding, and collections at Longwood Gardens in Chester County, Pennsylvania.

Illustration by Matt Huynh

Dosmann. We travelled the same route, stopping at some of the same plants, including the group of *Stewartia monadelpha,* this time being able to better focus and to make additional collections, including *Magnolia obovata, Magnolia salicifolia,* and *Trochodendron araliodes.*

But what drew us along that day was to again see a forest of *Sciaptopitys!* As we approached the trees from the main trail, we passed through an overstory of *Pinus parviflora* and naturally growing *Chamaecyparis obtusa* before reaching the almost-pure stand of umbrella pine. On this second visit, we had the time to slow down and appreciate the scene, taking more careful observations, and making sure that we collected two-year-old mature cones! The population was growing along a narrow ridge—no more than two or three meters wide—which dropped precipitously at least 100 meters on each side. A small path bisected this ridge, and the umbrella pines were found along roughly 75 meters up to the tip of the ridge. Not only were there towering mature trees (up to 25 meters!), but scattered below them were dozens of young seedlings, a promising sign of recruitment and the future of this small grove. It was an incredible scene, one that we all agreed was among the top few of our combined plant collecting moments. After carefully cleaning these cones, we returned with a collection of (viable) seeds, and with good germination, the resulting plants can be found in the production houses of several of our gardens.

Sciadoptiys verticillata, whose common name is a literal translation from the Greek for "whorled," "umbrella," and "pine," is not at all a pine but rather is the sole member of a monotypic family (Sciadopityaceae), closely allied with the Cupressaceae, or cypress family. It is listed as "near-threatened" by the IUCN, although its status has not been reviewed in more than a decade, so its population trends are currently unknown. Although our experience was limited to one location, this species' situation is perhaps precarious, and its population trends need better delineation. Future field work should include visiting and documenting the various known populations to gain a deeper understanding of their health and dynamics.

If you see an umbrella pine, it means there are other treasures to be found nearby.

Umbrella pine is endemic to Japan, with the Japanese name *koyamaki.* Populations occur in the southern prefectures of Honshu as well as on Kyushu, and Shikoku, where it is most abundant. The species was first introduced into the U.S. by Dr. George Rogers Hall in the early 1860s, and began making its way into commercial horticulture by the late 1800s. In his 1868 *Book of Evergreens,* Josiah Hoopes wrote that:

> This new and rare genus has lately been discovered in the mountains of Japan, and is very distinct in appearance from all others of the Coniferae. But one species is as yet known to botanists, and that forms a tall tree with very curious, whorled branches, and verticilled leaves.
>
> As the few plants in this country are as yet comparatively untested in open air, we cannot determine its powers of endurance, but we confidently believe that it will grow here with at least tolerable success.

Sciaptopitys has always been an indicator of a plant aficionado's garden, and usually if you see an umbrella pine, it means that there are other treasures to be found nearby. As one example, after the severe winter of 1933–34, Pierre du Pont searched for replacement evergreens for Longwood Gardens, including the purchase of a large umbrella pine from the nursery of Lewis and Valentine Company. This tree is still growing in its original location, and hopefully in time, the young seedlings from Japan can join it or other trees throughout the gardens. It is this iterative process of acquiring, growing, and re-acquiring important species that is a hallmark of perpetuating living collections.

It is not often that second chances come along, so the opportunity twice to visit such a remarkable population of umbrella pines has not been lost on us. We have retained the impression of its beauty, but more importantly, value our contribution to documenting and helping to preserve this unique species.

Sorbus yuana

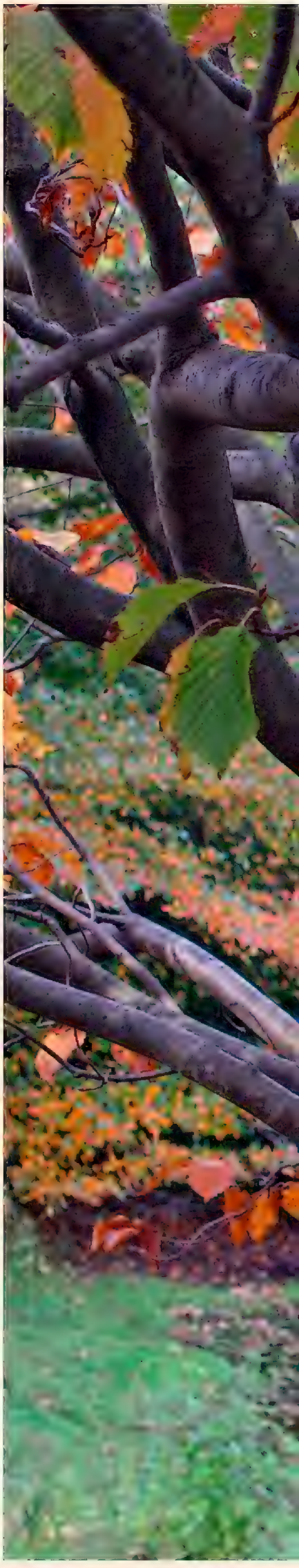
By Jon Hetman

A walk through the Arnold Arboretum landscape offers many opportunities to encounter botanical celebrity. For me, one easy-access meet-and-greet is accession 1539-80*B, *Sorbus yuana,* spreading its perfectly rounded canopy near the edge of Rehder Pond where Meadow Road meets Bussey Hill. Known as Yu's whitebeam, this handsome relative of mountain ash, which has flown under the radar in American horticulture, looks more than ready for a well-deserved close-up.

The debut of *S. yuana* at the Arnold Arboretum marked its introduction to Western horticulture. But in this case, discovery was preceded by mistaken identity. It was among the 621 plants collected during the first Sino-American Botanical Expedition in 1980, heralded as the reopening of China to western botanists after the Chinese Revolution. Arboretum taxonomist Stephen Spongberg later determined that some of the seeds and herbarium specimens identified as *S. zahlbruckneri* were a distinct species, bearing larger fruits and broader leaves with less regularly toothed margins. Publishing the species in 1986 in the *Journal of the Arnold Arboretum,* Spongberg named the plant to honor Professor T. T. Yu (俞德浚, Yu De Jun [pinyin], 1908–1986).

The single trunk and stiffly ascending branches of 1539-80*B provide the neat and tidy form that Spongberg and others have noted as typical of *S. yuana*. Its dark green leaves with a pale underside turn a golden- to apricot-yellow in synchrony and visual harmony with its autumnal red fruits. It flowers abundantly in May-June with clusters of white, star-shaped blossoms, which require another individual for fertile fruits. Fruits are dotted by tiny lenticels and are edible, described in a field note by keeper of the living collections Michael Dosmann as "nice, tasty, tart" in October 2008. In the absence of pollination, *S. yuana* can produce small, infertile, seedless fruits that are inedible but still attractive. This specimen (and apparently the species) has largely avoided any significant damage from fireblight and other disease issues prevalent among its North American kin.

Today, *S. yuana* is considered endangered in its native Chongqing and Hubei Provinces. In addition to this specimen, the living collections include a dozen individuals belonging to two additional accessions. In recent years, botanical scholars have argued for a reclassification of Yu's whitebeam, splitting it and several other Asian *Sorbus* species into the genus *Alniaria*, adding another complicating twist to its road to recognition.



Jon Hetman is associate director of external relations and communications at the Arnold Arboretum.

With Rehder Pond as backdrop, 1539-80*B exhibits the striking, upswept architecture typical of *S. yuana.* *Photograph by Jon Hetman*

HISTORY OF LANDSCAPE

Wilderness in History and Ecology

Edward K. Faison

Wilderness. Few environmental terms are so freighted with controversy and misunderstanding. To many it evokes awe-inspiring landscapes, nature unfettered by people and modernity, and the best strategy to protect forests, biodiversity, and a climate run amok. To others, it evokes erasing of indigenous peoples, a relic of colonialization, a misunderstanding of forest stewardship, and a recipe for ecological degradation.[1] In this article, I will attempt to reconcile these opposing views. Although this topic is global in its relevance and application, this article will focus on eastern North America, the region with which I am most familiar.

A boardwalk provides access to a stand of swamp tupelo (*Nyssa biflora*) in South Carolina's Congaree Wilderness. *Photograph courtesy of the author*

Origins and concepts of wilderness

The concept of wilderness—land uncultivated and uninhabited by people that is free to self-organize [2] —is as old as civilization itself, and perhaps far older. As human cultures formed semi-sedentary and permanent cultures, a duality emerged between land that was settled and land that was not; a perception of danger often permeated the latter.[3]

In the earliest work of literature, the Mesopotamian Epic of Gilgamesh (c. 4000 years ago), the leaders of Uruk say to their hero who plans to travel to the Cedar Forest to slay its formidable guardian: "Gilgamesh ... the forest stretches for ten thousand leagues in every direction; who would willingly go down to explore its depths?"[4]

Three millennia later in the Anglo-Saxon poem *Beowulf* (c. 700–1000 CE), the hero braves "an unvisited land among wolf-haunted hills, wind-swept crags, and perilous fen tracks" to slay the monster Grendel.[5]

This duality of the settled vs. the foreboding wild was not limited to European and Near Eastern civilization, but also appeared in advanced cultures of Mesoamerica. Of the classical Mayan civilizations of Mexico (250–900 CE), the Mesoamerican scholar Karl Taube wrote: "... the forest is a dangerous, uncontrollable place of demons and fierce, biting beasts. Although the Classic Maya may well have closely cared for and managed forests of valued woods, fruit trees, medicines, and other products, the fearsome way spirits suggest a more distant, wilder realm...."[6] The Aztecs too feared the forest beyond civilization, even as they used parts of the forest as a source of wood. The pioneering ethnographer Bernardino de Sahagun transcribed Aztec views of the forest in his sixteenth century Florentine Codex: "It is a disturbing place, fearful ... home of the wild beast.... There is no one.... It is desolate.... There is nothing edible. Misery abounds ... there is constant fright. One is devoured. One is slain by stealth ..."[7] Needless to say, there are striking parallels between the ancient Maya and Aztecs and ancient European and Near Eastern myths and sentiments about wild nature. The universality and convergence of human nature transcends culture and geography.

But fear was not the only emotion connected to unsettled land. In the ancient cultures of the Far East (beginning in the 5th century BCE), many Chinese artists and poets revered wild nature as a place to commune with God (even as others focused on its dangers and hostility). Painted scenes of wild nature were viewed as an antidote to the stifling confines of everyday life in civilization.[8] Fear and reverence, it turns out, are two sides of the same coin.

There were other human benefits assigned to experiencing wilderness, namely character building. Dating from pre-European North America, the semi-sedentary Nez Percé of the Pacific Northwest have a word that means "peopleless land" (*titoqanót wétes*). The peopleless land was generally in the high elevations of the Bitterroot Mountains, which became largely inaccessible for three seasons of the

1 These diverse views on wilderness protection can be found in Denevan, W. M. (1992). The pristine myth: the landscape of the Americas in 1492. *Annals of the Association of American Geographers*, 82(3), 369–385; Cronon, W. (1996). The trouble with wilderness: or, getting back to the wrong nature. *Environmental History*, 1(1), 7–28; Fletcher, M. S., Hamilton, R., Dressler, W., & Palmer, L. (2021). Indigenous knowledge and the shackles of wilderness. *Proceedings of the National Academy of Sciences*, 118(40), e2022218118; Watson, J. E., Shanahan, D. F., Di Marco, M., Allan, J., Laurance, W. F., Sanderson, E. W., ... & Venter, O. (2016). Catastrophic declines in wilderness areas undermine global environment targets. *Current Biology*, 26(21), 2929–2934; Nash, R. F. (2001). *Wilderness and the American Mind*. Yale University Press; Berlyn, G. P. et al. (2020). The Forest School GC3 Response Letter. Yale School of the Environment, The Forest School. New Haven, CT. https://forestpolicypub.com/wp-content/uploads/2023/03/Final_The-Forest-School-GC3-Response-1.pdf.

2 https://www.merriam-webster.com/dictionary/wilderness. Since the 1964 Wilderness Act, wilderness as a conservation policy has come to mean the formal designation—through legal or administrative process—of land protected from timber harvesting to remain in an untrammeled condition, rather than unsettled or unused land per se. This distinguishes wilderness from land currently unused but susceptible to management at a later date. See Foster, D. et al. (2023). *Wildlands in New England. Past, Present, and Future.* Harvard Forest Paper 34. Harvard University.

3 Nash, R. F. (2001). *Wilderness and the American Mind*. Yale University Press; Taube, K. A. (2003). *Ancient and Contemporary Maya Conceptions About Field and Forest* (pp. 461–492). Food Products Press.

4 https://open.maricopa.edu/worldmythologyvolume2heroicmythology/chapter/the-epic-of-gilgamesh/

5 Quotes from Nash, R. F. (2001).

6 Taube, K. A. (2003). Taube also noted that land outside of settled areas were potentially dangerous as buffer areas between two hostile or competing tribes.

7 de Sahagun, Bernardino. *Florentine Codex: General History of the Things of New Spain. Book 11 — Earthly Things*

year. It was into these mountains that the tribe sent their adolescent children alone as part of a week-long rite of passage ritual (*wéyekin*). An absence of people and any sign of their daily activities were integral to the *wéyekin*.[9]

The previous example complicates the prevailing notion that the concept of wilderness is the product of civilization and the colonization of the Americas and was absent from hunter-gatherer societies who lived inseparably from the land.[10] It is true that the Nez Percé did not view the Bitterroot Mountains as "wild," dangerous, and apart from their existence in the same sense that English Americans might have,[11] but they nonetheless distinguished the mountains as an unsettled counterpart to the lands that they regularly inhabited as part of their seasonal movements.[12]

The Nez Percé were not unique among Native American tribes in terms of recognizing unsettled land. In the eastern woodland cultures, the Delaware had words for "uninhabited tract" (*tauwatawk*) and "in the uninhabited land" (*tauwatawique*). Similarly, the Passamaquoddy-Maliseet languages from northern Maine include words meaning "wilderness" (*kataskomiq*) and "out in wilderness" (*elomahkiwik*).[13] The dichotomy between settled and uninhabited land is fundamental to the concept of wilderness and appears to be common to humanity, regardless of whether the culture is in a densely populated and permanent civilization or a semi-nomadic hunter-gatherer culture.[14]

Early Postclassic Mayan portrayal of the forest, featuring wild nature juxtaposed with a person near his dwelling. Detail of a mural from the Upper Temple of the Jaguars, Chichén Itzá. *From Taube (2003)*

(1963). Translated by Charles E. Dibble and Arthur J. O. Anderson. University of Utah Press, Salt Lake City.

8 Nash, R.F. (2001); Tin, T., & Yang, R. (2016). Tracing the contours of wilderness in the Chinese mind. *International Journal of Wilderness,* 22(2), 35–40.

9 Sabol Spezio, T. (2020) Titoqanót Wétes—Nez Percé in Hall, Marcus and Wilko Graf von Hardenberg, eds. "New Wilderness Babel: What does Wilderness Mean in Your Language?" Environment & Society Portal, Virtual Exhibitions. Version 2. Rachel Carson Center for Environment and Society. https://www.environmentandsociety.org/exhibitions/wilderness-babel/titoqanot-wetes-nez-perce

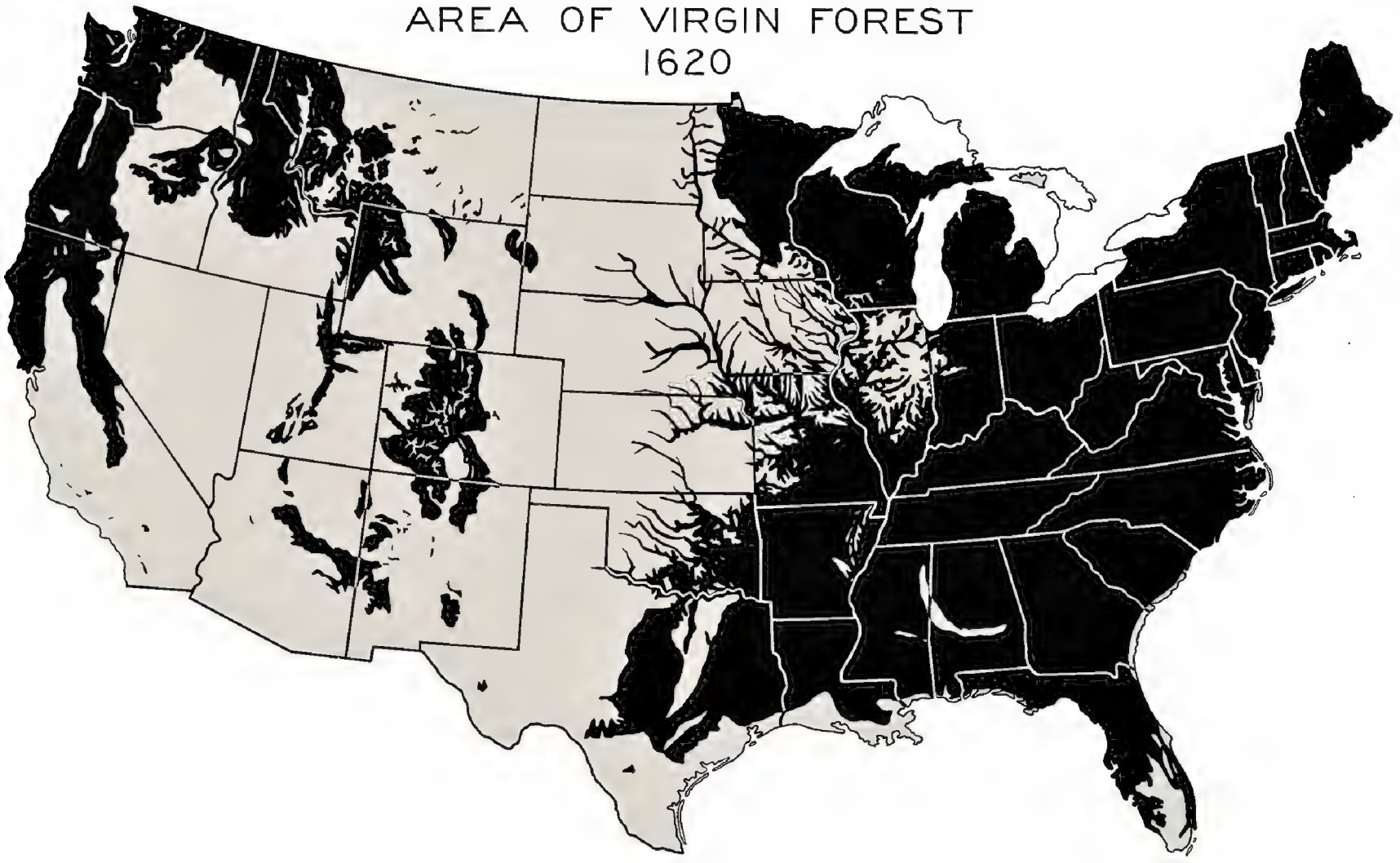
10 Nash, R. F. (2001) states: "... civilization created wilderness. For nomadic hunters and gatherers who represented our species for most of its existence, "wilderness" had no meaning. Everything natural was simply habitat, and people understood themselves to be part of a seamless living community."

11 Nash, R. F. (2001) quotes Chief Standing Bear of the Oglala Sioux (Born 1829) who said "only to the white man was nature a 'wilderness' and...the land infested with wild animals and savage people." [For Native Americans] "there was no wilderness since nature was not dangerous but hospitable." The critical distinction here seems to be that Standing Bear considered danger and hostility to be inherent in the definition of wilderness, which was undoubtedly an accurate assessment of English American (and the Aztecs and Mayan) views on the subject. However, wilderness at its core simply means 'uninhabited and unwilled land.' It is this latter meaning, stripped of its emotional connotations, where we find overlap between the Nez Percé and our modern American understanding of wilderness.

12 Sabol Spezio, T. (2020)

13 These Delaware (Lenape) words come from David Zeisberger's Indian dictionary, Zeisberger, D., & Horsford, E. N. (1887). *Zeisberger's Indian Dictionary.* New York: AMS Press. Zeisberger, a Moravian missionary and minister, lived with the Delaware (Lenape) tribe in the 1750s; Passamaquoddy-Maliseet Language Portal https://pmportal.org/

14 Rothenberg, J. (1980). Indians & wilderness. *Dialectical Anthropology*, 57–62.



Greeley's Virgin Forest map. *From Greeley, W. B. (1925)*

European perceptions of wilderness in eastern North America

One of the earliest European descriptions of the eastern North American landscape was by the Italian explorer Giovanni Verrazzano in 1524. Verrazzano's descriptions of the forests are notable because they are relatively neutral and even positive in tone. For instance, while observing the Carolina coast, Verrazzano did not see a terrifying wilderness but rather "an outstretched country ... covered with immense forests of trees, more or less dense, too various in colors, and too delightful and charming in appearance to be described."[15] Italian words for wilderness focus on the deserted, uninhabited character of the land and are generally not laden with negative emotions and danger,[16] which might help explain the tone of Verrazzano's language.[17]

In contrast, the English settlers who arrived at Plymouth, MA in 1620 viewed the landscape with much more foreboding. William Bradford described a "hideous and desolate wilderness."[18] The hostile wilderness viewpoint largely prevailed for the next century and a half in eastern North America, with John Adams noting in his diary in 1756 that "the whole continent was one continued dismal wilderness."[19]

Beginning in the late eighteenth and nineteenth centuries, naturalists, writers, and landscape painters—who were witnessing the increasing destruction of forests and wildlife by their fellow Europeans—began to extol the beauty and benefits of wild nature. In wilderness, the Romantics—like the ancient Far Eastern cultures over a millennia before them—found the highest expression of nature, the place closest to God, and the source for finding the pinnacle of human character.[20]

The Romantics are often portrayed as "inventing the American Wilderness" based in large part on their ignorance of the previous Native American influence on the land.[21] Yet, the naturalist William Bartram, perhaps the earliest champion of wilderness in America, was far from unaware of the land use activities of Native peoples. Traveling in Georgia in 1773, he came upon "the most magnificent forest I had ever seen ... sublime ... many of the black oaks measured eight, nine, ten, eleven feet diameter ..." Yet, nearby he also observed "many very magnificent monuments of ... the ancient inhabitants of these lands are visible ... I observed a stupendous conical pyramid ... vast tetragon terraces ... and certain traces of a larger Indian town ... the work of a powerful nation whose

period of grandeur perhaps long preceded the discovery of this continent."[22] Given its proximity, Bartram's magnificent forest was almost certainly once used, even tended, by the former civilization. The black oak trees, which can live over 250 years old,[23] likely supplied generations of people from the former culture with acorns, as well as meat from animals that foraged on the acorns (deer, bear, turkey). Burning, fuelwood removal, and tending by the former inhabitants may have even helped promote these oaks by reducing competition from other trees.

Bartram evidently saw little contradiction between a "sublime" forest and one that was previously inhabited and used. This addresses an important and often misunderstood point about wilderness—that it needn't be (and often isn't) pristine in the sense of never having been significantly manipulated by humans in the past; it just needs to be largely shaped by natural processes today and remain so into the future. Indeed, the 1975 Eastern Wilderness Act made this point clear when it established wilderness areas in US National Forests across 13 eastern states in lands that had been previously (and relatively recently) managed by European Americans. The key provision outlined in the original 1964 Wilderness Act is that land is maintained in an "untrammeled" (i.e. undirected and unrestrained) condition going forward.[24] The 2.7 million-acre Adirondack Forest Preserve in New York is the most prominent example of a state-owned wilderness that is not pristine. Designated as "forever wild" by an act of the state legislature in 1894, most of the preserve was logged by Europeans prior to being protected. It has nonetheless become the most iconic wilderness landscape in the eastern United States.[25]

While Bartram was the champion of eastern American wilderness in the eighteenth century, Henry Thoreau held that mantle in the nineteenth. Thoreau, for his part, was also knowledgeable of the impacts of Native Americans, albeit with fewer direct observations than Bartram. After reading William Woods' c. 1633 account of the eastern Massachusetts landscape, Thoreau wrote in his diary that "[the Native Americans] regularly cleared extensive tracts for cultivation ..." and "one would judge from accounts that the woods were clearer than the primitive wood that is left, on account of Indian fires ..." But Thoreau also recognized previous Native American land use as occurring on a completely different scale and intensity—because it still left much of the landscape and its life forms intact—than what he was experiencing in mid-nineteenth century Concord, Massachusetts: "But when I consider that the nobler animals have been exterminated here—the cougar,

15 *The Voyage of John de Verrazzano, along the Coast of North America, from Carolina to Newfoundland, A.D. 1524.*

16 Piccioni, L. (2020). A Language Without Wilderness—Italian, in Hall, Marcus and Wilko Graf von Hardenberg, eds. "New Wilderness Babel: What does Wilderness Mean in Your Language?" Environment & Society Portal, Virtual Exhibitions. Version 2. Rachel Carson Center for Environment and Society https://www.environmentandsociety.org/exhibitions/wilderness-babel/language-without-wilderness-italian; Adams, W. (2020). Wilderness—England's English, in in Hall, Marcus and Wilko Graf von Hardenberg, eds. "New Wilderness Babel: What does Wilderness Mean in Your Language?" Environment & Society Portal, Virtual Exhibitions. Version 2. Rachel Carson Center for Environment and Society. https://www.environmentandsociety.org/exhibitions/wilderness-babel/wilderness-englands-english

17 Verrazzano was also sailing for and reporting to the King of France, so he was more apt to speak in positive terms of the lands he was observing.

18 Nash, R. F. (2001).

19 Pearce, F. (2022). *A Trillion Trees: Restoring Our Forests by Trusting in Nature.* Greystone Books Ltd.

20 Nash, R. F. (2001).

21 Denevan, W. M. (1992).

22 Bartram, W. A. (1976). *Travels and Other Writings*. Princeton: Princeton University Press.

23 Eastern Oldlist (2024). https://www.ldeo.columbia.edu/~adk/oldlisteast/.

24 The confusion about wilderness needing to be pristine originates, in part, from a clause in the 1964 Wilderness Act definition that wilderness is "...land retaining its primeval character and influence...which generally appears to have been affected primarily by the forces of nature..." However, the passage of the 1975 Wilderness Act made it clear that previous logging and other human management did not disqualify lands from being designated and managed as wilderness into the future. Two US Senators who worked on the wilderness bills in 1964 and 1975 roundly dismissed the notion that wilderness needed to be historically pristine. Henry Jackson called this a "serious and fundamental misinterpretation of the Wilderness Act," (https://en.wikipedia.org/wiki/Eastern_Wilderness_Areas_Act), and Frank Church said that "Nothing could be more contrary to the meaning and intent of the Wilderness Act." Quoted in Foreman, D. (2014). The myth of the humanized pre-Columbian landscape. *Keeping the Wild: Against the Domestication of Earth,* 114–125.

25 Davis, J. (2015). Letting it be on a continental scale: some thoughts on rewilding. *Protecting the Wild: Parks and Wilderness, the Foundation for Conservation,* 109–119.

panther, lynx, wolverine, wolf, bear, moose, deer, the beaver, the turkey, etc., etc.— I cannot but feel as if I lived in a tamed, and, as it were, emasculated country ..."[26] And indeed it was. Thus, when Thoreau suggested that we "should preserve a certain sample of wild nature" so that it "may still exist and not be civilized off the face of the earth,"[27] he was including in wild nature the forest and all its animal inhabitants that had once co-existed with native peoples prior to European settlement.

Thoreau's pleas notwithstanding, the pace of environmental destruction only increased in the second half of the nineteenth century across the Eastern US and Great Plains. Logging and timber production peaked at the turn of the twentieth century, while most of the large mammals—grey wolves, bison, elk, cougars, and wolverines—were exterminated from the eastern United States.[28] At least four bird species were driven extinct from habitat loss and/or overhunting, most notably the Passenger Pigeon and the Ivory-Billed Woodpecker.[29]

It was on the heels of this destruction that the US Forest Service Chief WB Greeley published a paper and series of maps in 1925 showing the extent and loss of "virgin forests" in the United States since 1620.[30] In the 1620 map we see virtually the entire eastern United States covered by a sea of virgin forest except for those areas that were naturally grassy vegetation—the Prairie Peninsula in central and northern Illinois, the Everglades in Florida, the crescent-shaped Blackbelt Prairie in Mississippi and Alabama, and the Blackland Prairie of eastern Texas. There are no Native American settlements and agricultural fields, no open lands along the coast and river valleys, and no thinned and open forests from centuries of burning and fuelwood gathering. This errant perspective of the virgin forest took hold with the public, along with many authors, environmentalists and scientists.[31]

The pristine myth and reality

In 1992, the geographer William Deneven published *The Pristine Myth: the Landscape of the Americas in 1492* as a rebuttal to the notion that America was a pristine and largely empty wilderness prior to European settlement. The Wilderness Myth was reiterated by William Cronon in his influential 1996 essay *The Trouble with Wilderness* and popularized widely in Charles Mann's 2005 book *1491*.[32]

Deneven, Mann, and others argued that the Americas, including the seemingly most remote wilderness areas on Earth such as the Amazon rainforest were not pristine, virgin forests, but actually once populated and intensively used by native peoples. Perhaps 60 million people lived in the Americas in total, with about 4 million people north of Mexico.[33] According to these authors, it wasn't until over 90% of American Indian populations succumbed to European diseases, resulting in the abandonment of settlements and agricultural field and the subsequent regrowth of forests, did the perception of the virgin American wilderness come into being in the eighteenth and nineteenth centuries.

There is certainly some truth to these arguments. There were over a million Native peoples in in the Eastern United States in 1500 CE,[34] and when we look to the accounts of the first European explorers prior to the devastating disease epidemics, we clearly see examples of Native American impacts on the landscape. Not only were there extensive clearings and

26 Foster, D. R. (1999). *Thoreau's Country: Journey Through a Transformed Landscape*. Harvard University Press.

27 Nash, R. F. (2001).

28 Williams, M. (1992). *Americans and their Forests: a Historical Geography.* Cambridge University Press. Alverson, W.S., Waller, D. and Kuhlmann, W. (2013). *Wild Forests: Conservation Biology and Public Policy.* Island Press. Whitney, G.G. (1996).

29 Askins, R.A. (2014). *Saving the World's Deciduous Forests: Ecological Perspectives from East Asia, North America, and Europe.* Yale University Press.

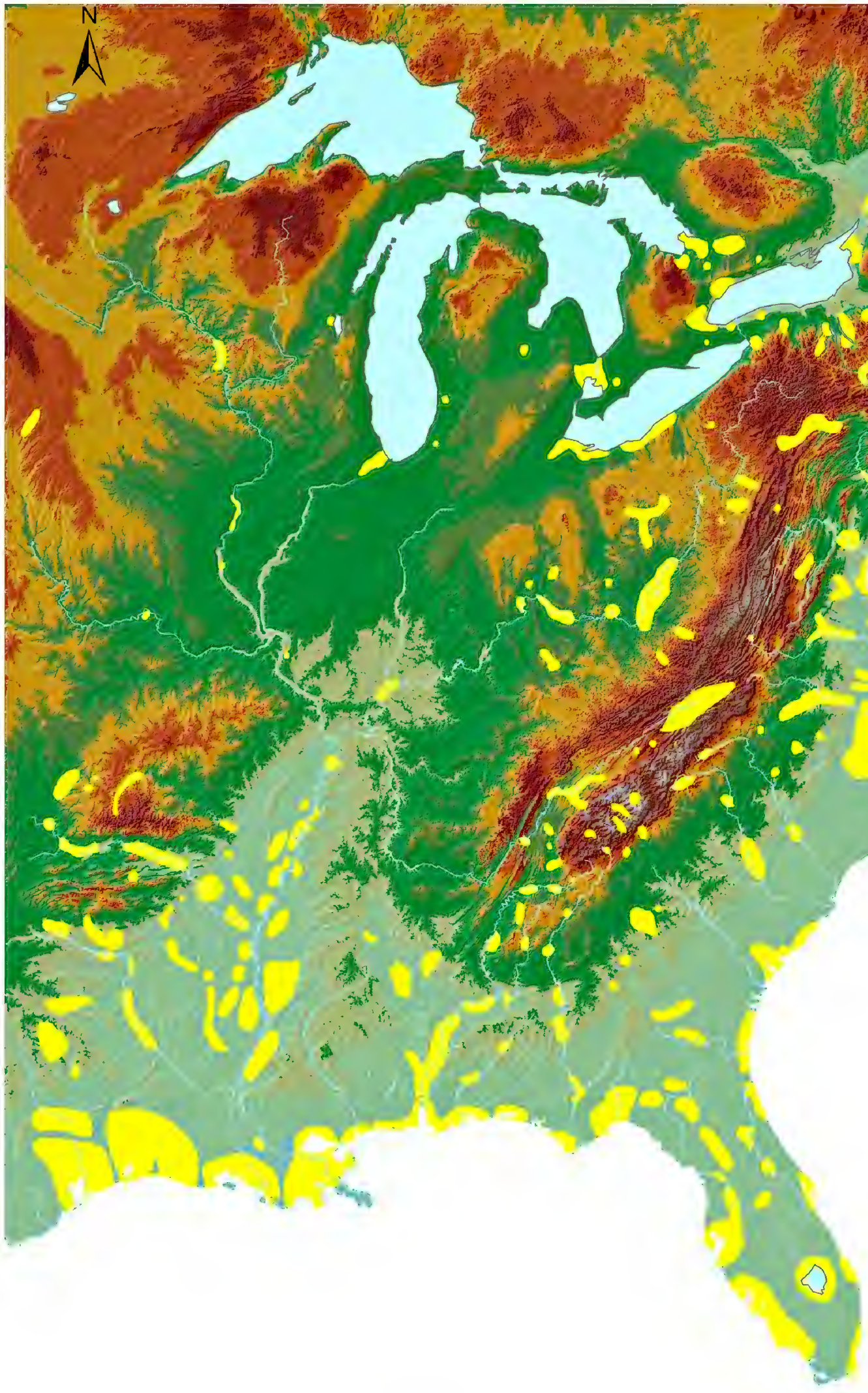
30 Greeley, W. B. (1925). "The Relation of Geography to Timber Supply." *Economic Geography* 1: 1–11; Peterken (1996) defined virgin forest as forest "never having been significantly influenced by people and implies an unbroken history of natural development"; however, it can often mean not influenced by technologically advanced societies. In either case, Greeley's map completely ignores the important impact of human cultures on eastern American forests prior to 1620. Peterken, G.F. (1996). *Natural Woodland: Ecology and Conservation in Northern Temperate Regions*. Cambridge University Press.

31 Denevan, W. M. (1992); See for example Miller, P. (2009). *Errand into the Wilderness* (Vol. 81). Harvard University Press and Waller, D. and Kuhlmann, W. (2013). *Wild Forests: Conservation Biology and Public Policy.* Island Press.

32 Denevan, W. M. (1992); Mann, C.C. (2005). *1491: New Revelations of the Americas before Columbus*. Knopf; Cronon, W. (1996). "The Trouble with Wilderness: or, Getting Back to the Wrong Nature." *Environmental History*, 1(1), 7–28.

33 Deneven, W. M. (1992); Milner, G. R., & Chaplin, G. (2010). "Eastern North American Population at ca. AD 1500." *American Antiquity,* 75(4), 707–726.

34 Milner, G. R., & Chaplin, G. (2010).



Population settlement locations of Native Americans at 1500 CE in the eastern United States. *Data from Milner and Chaplin (2010)*

settlements in many areas, but the forest itself was often notably open and thinly treed. For example:

> Samuel Champlain in Boston Harbor, MA (1605): "All along the shore there is a great deal of land cleared and planted with Indian corn."
>
> John Smith, Jamestown. Virginia (1607): "the [Native American] houses are in the midst of their fields or gardens, which are small plots of ground. Some 20 acres, some 40, some 100, some 200, some more, some less. In some places some 20 to 50 of those houses together ... Near their habitations is little small wood or old trees on the ground by reason of them burning of them by fire. So that a man may gallop a horse amongst the woods any way."
>
> Garcilaso, Georgia (1539): "The land of Ocute ... has the most open forest and very excellent fields along the rivers."
>
> Garcilaso, Northwestern Florida (1539): "The first two leagues beyond the river the land consisted of open plains and the next four of cultivated fields ... Ugachile had 200 houses."[35]

Corroborating these historical accounts, fossil pollen and charcoal evidence obtained from sediment cores reveal significant non-forest vegetation and fire in many locations along the East Coast prior to European settlement. Some examples include the outwash plain of Martha's Vineyard, Massachusetts, extensive cultivation and open vegetation in southern Ontario and along the Little Tennessee River Valley in eastern Tennessee, and cultivated vegetation and burning in the nearby highlands of North Carolina.[36]

But how much land did the Native Americans inhabit and use in 1500 CE? And how do we reconcile the above accounts with others that suggest a very different landscape character? For instance:

> Jacques Cartier, exploring the region around the mouth of the Saint Lawrence River, New Brunswick (1535–1536): "... the land is not tilled nor full of people; and it is all full of woods ..."
>
> Samuel Champlain, exploring the inlets of Passamaquoddy Bay along New Brunswick and Maine Coast (1604): "[aside from an area in which] there are 15 to 20 acres of cleared land ... all the rest of the country is covered with very thick forests."
>
> John Smith, Virginia (c. 1607–1609): "By the rivers are many plaine marishes, containing some 20 some 100. some 200 Acres, some more, some lesse. Other plaines there are few, but onely where the Salvages inhabit: but all overgrowne with trees & weeds, being a plaine wildernesse as God first made it."
>
> Hernando De Soto between Florida and Georgia (c.1540): "[we passed through] a lean land, and most of it covered with rough pine groves, low and very swampy, and in places having lofty dense forests, where ... the horses [could not] enter ..."[37]

The human population density provides some critical perspective. At 1500 CE, the population of eastern North America is estimated to have been ~1.6 million people,[38] which is slightly higher than the population of the state of New Hampshire today. Distributed across 1.2 million square miles of what is now the eastern United States, an area 133 times larger than New Hampshire, this population size results in an average of 1.3 people per square mile. To put that number into perspective, the US Census Bureau in 1890 defined as "unsettled" land with less than 2 people per square mile.[39] Locally much higher population densities and settlement patterns were clustered along the resource-rich coast and river valleys, which left many inland areas far below the average. Additionally, substantial areas of resource-rich land remained unsettled resulting in scattered population centers.[40]

What emerges from this density estimate and a comprehensive map of settlement locations (Fig. 3) is the extent to which Native American land use impacted large areas of the eastern United States AND the extent to which there were vast and far more extensive unoccupied areas across this region at 1500 CE.[41] Along much of the Gulf Coast and eastern seaboard (with the exception of the Carolinas) and many major rivers, the notion of a pristine wilderness is inconsistent with previous American Indian occupation.[42] Forest composition, structure, and age in these areas, particularly within dense population clusters, were notably shaped by Native American agricultural and silvicultural activities. For example, in the abandoned fields and settlements of the Iroquois in southern Ontario, white pine forests grew back in what was previously beech-maple deciduous forest. But beyond tens of kilometers around settlements and travel corridors, the land was generally uninhabited and only lightly used if at all. In these wilderness areas, human impacts were "indistinguishable from other drivers of environmental heterogeneity."[43]

Examples of these uninhabited areas in the southeastern US are confirmed by Hernando De Soto's expedition (1539–1543)—the first European expedition into the southeastern U.S. prior to the devastating disease epidemics, presumably wrought by De Soto himself and other Europeans. His army

traveled through 60 leagues (~150 miles) of "desert," (the Spanish term for unpopulated lands) from modern day Tallahassee, Florida to central Georgia. Then De Soto marched 9-10 days through 80 leagues (~200 miles) of another uninhabited stretch between Ocute in northeastern Georgia and Cofitachequi in South Carolina.[44]

But 1500 CE is still just a snapshot in time in the pre-European past. It is important to consider that large agricultural population centers developed between 900 and 1300 CE—most spectacularly at Cahokia in the central Mississippi valley—and that many of these settlements shrank, relocated, or disappeared by 1500 CE (Fig. 4).[45] For instance, the Great Lakes region of Michigan, the Ohio River Valley, and large parts of the Midwestern US that were uninhabited in 1500 CE were settled in earlier centuries. Other areas remained, to the best of archaeological knowledge, uninhabited during these centuries.[46] Thus, an important distinction can be made between wilderness that was not pristine in the sense of having been settled and/or managed in the past (e.g., Bartram's magnificent black oak forest described above) and wilderness that was very likely pristine in the sense of having been only very lightly used but never settled.[47]

A skeptic may point to the incomplete archaeological record as not reflecting the full extent of Native American settlements and impacts on the landscape. Although small sites (fire pits and temporary camps) have undoubtedly been missed by archaeologists, it is unlikely, according to the archaeologist George Milner, that significant population centers have been overlooked during the past century of archaeological investigation.[48]

Eastern North America was a thriving and

35 These quotes represent just a few of the many examples. Quotes obtained from Williams, M. (1992). Americans and their forests: a historical geography. Cambridge University Press. Alverson; Swanton, J. R. (1985). Final report of the United States De Soto Expedition, Smithsonian Institution Press; The voyages and explorations of Samuel de Champlain 1604–1616. https://libsysdigi.library.uiuc.edu/oca/Books2008-05/voyagesexplorati/voyagesexplorati-01cham/voyagesexplorati01cham.pdf?ref=quillette.com.

36 Cridlebaugh, P. A. (1984). *American Indian and Euro-American impact upon Holocene vegetation in the lower little Tennessee River Valley, East Tennessee.* The University of Tennessee; Stevens, A. (1996). *The Paleoecology of Coastal Sandplain Grasslands on Martha's Vineyard, Massachusetts*. University of Massachusetts Amherst; Munoz, S. E., Mladenoff, D. J., Schroeder, S., & Williams, J. W. (2014). "Defining the Spatial Patterns of Historical Land Use Associated with the Indigenous Societies of Eastern North America." *Journal of Biogeography,* 41(12), 2195–2210. Delcourt, H. R., & Delcourt, P. A. (1997). "Pre-Columbian Native American Use of Fire on Southern Appalachian Landscapes." *Conservation Biology,* 11(4), 1010–1014.

37 Swanton, J. R. (1985).

38 Native American population estimate from Milner, G. R., & Chaplin, G. (2010), which is about a half million people higher than that estimated by *National Geographic* in 2007 (*National Geographic: Colonial America 1491 vs. 1650 – A World Transformed*).

39 US Census Bureau (2012). Following the frontier line, 1790 to 1890. https://www.census.gov/dataviz/visualizations/001/.

40 See Munoz et al. (2014) and Milner and Chaplin (2010).

41 Milner and Chaplin (2010).

42 However, as noted before, a pristine or virgin quality is not a necessary requirement of wilderness designation. It does, however, address the question of whether the land had a lengthy history of human land use.

43 Quote from Munoz, S. E., Mladenoff, D. J., Schroeder, S., & Williams, J. W. (2014). "Defining the Spatial Patterns of Historical Land Use Associated with the Indigenous Societies of Eastern North America." *Journal of Biogeography*, 41(12), 2195–2210. Munoz et al. (2014) also provided the example of the pine forests regrowing on abandoned Iroquois settlements. See also Tulowiecki, S. J., Ranney, E. R., Keenan, E. M., Neubert, G. M., & Hogan, M. L. (2022). "Localized Native American Impacts on Past Forest Composition Across a Regional Extent in Northeastern United States." *Journal of Biogeography*, 49(6), 1099–1109. These authors concluded that "Native American land use had no detectable effect on forest composition across a regional extent, but increased the abundance of fire-tolerant, shade-intolerant and nut-producing trees locally."

44 Swanton, J. R. (1985). *Final Report of the United States De Soto Expedition*, Smithsonian Institution Press.

45 The empty Northeastern US in Fig. 4 reflects the scarcity of archaeological data, rather than a truly vacant region over time. Figure 3 is a more accurate reflection of the populated areas in the Northeastern region 1500 CE.

46 However, as noted before, a pristine or virgin quality is not a necessary requirement of wilderness designation. It does, however, address the question of whether the land had a lengthy history of human land use.

47 An example of the former can be found in the De Soto expedition. In northcentral Florida, De Soto "passed an uninhabited region ten or twelve leagues in extent...in which there are large forests of walnut, pines, and other trees...They all appeared to have been set out by hand there being so much space from one to another than horses could even run between them..." It seems plausible that the expedition was passing through a wilderness that had been, at least in part, altered by human management in centuries past.

48 Milner and Chaplin (2010).

Forests, it turns out, are not dependent on human beings to produce thriving, complex, and diverse structures.

peopled landscape in 1500 CE, and to an even greater extent for many centuries beforehand. It was also a wilderness landscape in which most of the land area remained unsettled and very lightly affected by people. Both of these ideas are true simultaneously.[49]

The condition of wilderness forests

Although the concept of wilderness is a cultural construct, wilderness nonetheless reflects a physical reality in which certain landscapes are primarily or completely outside the realm of human intervention or direction. If large areas of eastern North American forests grew under Native American management at some time between 1000 and 500 years ago, and perhaps even larger areas appear to have grown and self-organized largely independent of human beings, what are the implications for the health of forests growing today in protected wilderness areas that are unaided by management? Do forests require human management to prevent degradation as some have suggested?[50]

In 2002, forest ecologist Jerry Franklin and colleagues published an influential paper on the development of "natural forests" (those unmanaged by people).[51] The authors showed how such forests develop a complex arrangement of structures as they age—i.e., dead standing and downed trees, and large old trees—regardless of, and in large part because of, what nature throws at them in terms of natural disturbances. The authors argued that contemporary forest management could do a better job of protecting biodiversity and ecological processes and functions by emulating the structural development in older, natural forests. Forests, it turns out, are not dependent on human beings to produce thriving, complex, and diverse structures. Rather, undirected forests exposed to the whims of nature result in forest conditions that forest managers would do well to learn from and apply to their management practices.

This is hardly surprising. North America's eastern deciduous forests evolved and developed over 60 million years in the absence of people before humans crossed the Bering Land Bridge and arrived on the scene about 15,000 years ago.[52] This is not to say that land use activities of Native Americans didn't create diverse vegetation structures and benefit certain species—they certainly did[53]—but that forests are by no means dependent on such activities by people for complexity, diversity, function, and habitat.

Subsequent research in the eastern United States has not only borne out the idea of the self-sustaining natural forest, but that wilderness and wilderness-like forests are generally in better condition than those that are not protected from human

activities. Two papers authored by National Park Service ecologists in 2016 and 2018 compared dozens of National Park forests in the eastern United States to unprotected forests exposed to management. The authors led by Kate Miller reported greater structural complexity in terms of large live and dead trees, large dead wood on the forest floor and greater tree species diversity in the park forests.[54]

A more recent paper that I published with colleagues in 2023 reported similar results in wildland (aka wilderness) forests of the Northeastern US: structural complexity (diversity of tree diameter size classes, density of large live and large dead trees, and maximum tree height) were all greater in wildland forests than in forests exposed to management.[55] Notably, we observed the greatest discrepancies in forest condition in wilderness areas that had been protected for the longest time—i.e., in the Adirondack and Catskill Forest Preserves that were designated as "forever wild" over a century ago. In short wilderness designation does not result in forest degradation, as some have proposed. Just the reverse happens.

Increased structural complexity and tree species richness generally provide greater resources and habitat niches and thus are predictors of overall biodiversity.[56] In a 2014 paper, researchers from the University of Minnesota found that bird species richness, density, and abundance of individual species were all higher in wilderness forests compared to adjacent managed forests in Superior National Forest.[57] Notably, the number of "early successional" bird species—those species that prefer young, scrubby habitats rather than mature forests—did not differ between the two management categories. Early successional species can benefit from human management that creates young, shrubby vegetation;[58] but importantly these species don't require such management to survive. Indeed, the Minnesota researchers found that natural openings from treefalls, beaver ponds/

49 Vale, T. R. (2000). Pre-Columbian North America: Pristine or Humanized-or Both? *Ecological Restoration,* 18(1), 2–3.

50 Fletcher, M. S. et al. (2021); Berlyn, G. P. et al. (2020).

51 "Natural forests" are largely synonymous with wilderness forests. Franklin, J. F., Spies, T. A., Van Pelt, R., Carey, A. B., Thornburgh, D. A., Berg, D. R., ... & Chen, J. (2002). "Disturbances and Structural Development of Natural Forest Ecosystems with Silvicultural Implications, Using Douglas-fir forests as an Example." *Forest Ecology and Management*, 155(1–3), 399–423.

52 Askins, R.A. (2014).

53 See Whitney (1996) and Munoz et al. (2014).

54 Miller, K. M., Dieffenbach, F. W., Campbell, J. P., Cass, W. B., Comiskey, J. A., Matthews, E. R., ... & Weed, A. S. (2016). "National Parks in the Eastern United States Harbor Important Older Forest Structure Compared with Matrix Forests." *Ecosphere*, 7(7), e01404; Miller, K. M., McGill, B. J., Mitchell, B. R., Comiskey, J., Dieffenbach, F. W., Matthews, E. R., ... & Weed, A. S. (2018). "Eastern National Parks Protect Greater Tree Species Diversity Than Unprotected Matrix Forests." *Forest Ecology and Management*, 414, 74–84. See Miller, K. M., McGill, B. J., Weed, A. S., Seirup, C. E., Comiskey, J. A., Matthews, E. R., ... & Paul Schmit, J. (2021). Wilderness forests, particularly those in proximity to human development, are not immune to the spread of invasive plants, as many of these National Park forests have seen increases in invasive plants over time. See Miller, K. M., McGill, B. J., Weed, A. S., Seirup, C. E., Comiskey, J. A., Matthews, E. R., ... & Paul Schmit, J. (2021). "Long-Term Trends Indicate that Invasive Plants are Pervasive and Increasing in Eastern National Parks." *Ecological Applications*, 31(2), e02239. However, tree cutting almost invariably promotes greater invasive plant abundance in managed forests than in forests that are left uncut. See Wilms et al. 2017. "The Effects of Thinning and Burning on Understory Vegetation in North America: a Meta-Analysis." *Forest Ecology and Management*.

55 Faison, E. K., Laflower, D., Morreale, L. L., Foster, D. R., Hall, B., Johnson, E., & Thompson, J. R. (2023). "Adaptation and Mitigation Capacity of Wildland Forests in the Northeastern United States." *Forest Ecology and Management*, 544, 121145.

56 McElhinny, C., Gibbons, P., Brack, C., & Bauhus, J. (2005). "Forest and Woodland Stand Structural Complexity: its Definition and Measurement. F*orest Ecology and Management*, 218(1–3), 1–24.

57 McElhinny, C., Gibbons, P., Brack, C., & Bauhus, J. (2005). "Forest and Woodland Stand Structural Complexity: its Definition and Measurement. F*orest Ecology and Management*, 218(1–3), 1–24.

58 See for example the recent review paper by Akresh, M. E., King, D. I., McInvale, S. L., Larkin, J. L., & D'Amato, A. W. (2023). "Effects of Forest Management on the Conservation of Bird Communities in Eastern North America: A Meta-Analysis." *Ecosphere*, 14(1), e4315.) The authors reported that recently managed (<16 years since cutting) forests had higher bird conservation value than unmanaged forests, in large part because of their habitat benefits for early successional bird species. However, their analysis "excluded studies examining the effects of fire or other natural disturbances." from the unmanaged forest category. Given that natural disturbances are the key drivers of structural complexity and biodiversity in natural forests, one cannot conclude from Akresh et al. (2023) that wilderness forests do not provide adequate habitat for early successional forest species. In contrast, Zlonis and Niemi (2014) cited above and in the text did include the full range of forest conditions and natural disturbances in their study.

Complexity and species diversity also go hand in hand with the resilience of the forest.

meadows, floodplains, and other disturbances provided those habitats naturally, as they undoubtedly did for millions of years before humans arrived in North America.[59]

Greater structural complexity and species diversity also go hand in hand with the resilience of the forest (i.e., the capacity of forests to recover from disturbance), a particularly relevant quality in our current age of climate change and increased forest disturbances. In a recent global analysis of forest resilience in the journal *Nature,* the authors concluded the following: "Intact [i.e., unmanaged] forests have considerably ... higher forest resilience than managed forests... This finding reinforces the expectation that intact forests have a higher capacity to withstand external perturbations."[60]

In addition to resilience, the capacity of forests to accumulate and store carbon (aka their "climate mitigation capacity") is a critical ecosystem service with ever increasing carbon dioxide levels in the atmosphere. Our 2023 paper mentioned above found that wildland forests stored 20% more aboveground carbon (carbon in both live and dead trees) than in

59 Additionally, the frequency and intensity of weather related disturbances such as windthrow and insect outbreaks are on the rise in recent decades and are expected to continue to increase with climate change, providing greater amounts of young, shrubby vegetation that will benefit early successional species. See Parmesan, C., Morecroft, M. D., Trisurat, Y., Adrian, R., Anshari, G. Z., Arneth, A., Gao, Q., Gonzalez, P., Harris, R., Price, J., Stevens, N., & Talukdarr, G. H. (2022). "Terrestrial and Freshwater Ecosystems and Their Services. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 197–377). Cambridge University Press. https://doi.org/10.1017/9781009325844.004.

60 Forzieri, G., Dakos, V., McDowell, N. G., Ramdane, A., & Cescatti, A. (2022). "Emerging Signals of Declining Forest Resilience Under Climate Change." *Nature*, 608(7923), 534–539.

61 Faison, E. K. et al. (2023).

62 Nunery, J. S., & Keeton, W. S. (2010). "Forest Carbon Storage in the Northeastern United States: Net Effects of Harvesting Frequency, Post-Harvest Retention, and Wood Products." *Forest Ecology and Management*, 259(8), 1363–1375.

63 However, it is important to note that not all indigenous stewardship and management is enlightened and beneficial, and that regardless of ethnicity, high human population densities, human migration into previously unpeopled lands, and access to technology have historically played a large role in human impacts on forests and wildlife, including local and global extinctions of species. See Wilson, E. O. (1999). *The Diversity of Life*. W. W. Norton & Company; Diamond, J. (2011). *Collapse: How Societies Choose to Fail or Succeed* (revised edition). Penguin. Estrada, A., Garber, P. A., Gouveia, S., Fernández-Llamazares, Á., Ascensão, F., Fuentes, A., ... & Volampeno, S. (2022). "Global Importance of Indigenous Peoples, Their Lands, and Knowledge Systems for Saving the World's Primates from Extinction." *Science Advances*, 8(31), eabn2927.

64 Waller, D. M., & Reo, N. J. (2018). "First Stewards: Ecological Outcomes of Forest and Wildlife Stewardship by Indigenous Peoples of Wisconsin, USA." *Ecology and Society.*

65 Sze, J. S., Childs, D. Z., Carrasco, L. R., & Edwards, D. P. (2022). "Indigenous Lands in Protected Areas Have High Forest Integrity Across the Tropics." *Current Biology*, 32(22), 4949–4956; Schuster, R., Germain, R. R., Bennett, J. R., Reo, N. J., & Arcese, P. (2019). "Vertebrate Biodiversity on Indigenous-Managed Lands in Australia, Brazil, and Canada Equals That in Protected Areas." *Environmental Science & Policy*, 101, 1–6; Monitoring of the Andean Amazon Project (2023) MAAP #183: Protected Areas & Indigenous Territories Effective Against Deforestation Across Amazon | MAAP (maaproject.org).

66 Sze et al. (2022).

67 Pearce, F. (2022).

68 Faison, E. K. (2021). "Backyard Climate Solutions." *Arnoldia*, 78(3), 28–37.

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unprotected forests overall.[61] Researchers from the University of Vermont examined the relationship between carbon and forest management more thoroughly. They calculated the carbon accumulated in forests exposed to a wide range of forest management approaches, ranging from the most intensively managed clearcuts to the least intensively managed 'structural retention harvests.' Interestingly the retention harvests significantly outperformed the clearcuts in terms of carbon accumulation; however, the unmanaged forests outperformed all of the managed forest scenarios, even when the stored carbon that remained in harvested wood products was included in the managed forest totals.[62]

Indigenous stewardship and wilderness

Not all forms of forest management are equivalent in terms of their impacts and ability to retain structures and species. Contemporary Native American forest and wildlife management are, in some cases, more progressive and less impactful than those of modern European-American systems.[63] For example, in Wisconsin, the Menominee and Ojibwe tribes value old trees and forests, and consequently manage their tribal forests for longer rotations and larger trees. Menominee County, in which the tribal lands are located, is also the least populated county in Wisconsin; thus, low population densities undoubtedly contribute to the relatively light touch on the tribal forests. These forests, in turn, store more carbon than national forests managed by the USDA Forest Service located just outside the reservation. The Menominee and Ojibwe also value and protect large carnivores such as wolves, resulting in reduced deer browsing pressures and increased tree seedling densities on their tribal lands.[64]

At a global scale, indigenous territories often rival "protected areas"—which include wilderness area but also less strictly protected lands that allow some management—in terms of greater connectivity, greater vertebrate diversity, reduced forest loss, and greater forest integrity than surrounding unprotected and non-indigenous lands.[65] One recent study showed that indigenous lands that overlapped with protected areas in South America achieved the highest forest integrity scores in the world; however, these areas also had the highest proportion of wilderness forests.[66] Thus, it's unclear what exactly is driving the enhanced conservation performance of these areas. Is it indigenous stewardship—most notably better protection against illegal logging/mining/hunting than protected areas that are under government control[67]—or is it the existing high percentage of wilderness? The choices are to some extent interdependent, and like many such questions, the answer is probably both/and rather than either/or.

Concluding thoughts

Just as it is clear that over a million Native Americans lived in and altered parts of the landscape of the eastern United States prior to Columbus, it is also clear that uninhabited, wilderness-like conditions existed across vast areas of this region at 1500 CE. Many of these uninhabited areas were once inhabited by Native American cultures centuries earlier; many others were apparently never inhabited.

Forest ecosystems generally thrive in a wilderness condition, achieving high levels of complexity, diversity, and carbon storage relative to managed areas; but of course, wilderness conditions do not provide everything that people need (i.e., wood, fuel, crops, shelter) and thus cannot and do not exist everywhere. And, as William Cronon argued, we can find considerable joy and satisfaction in the wildness and naturalness in our own backyards—something that I too have written about[68]—if, that is, we are open to seeing it.[69]

Yet, the nature near our dwellings will always feel different to us than the nature of unsettled areas outside of human influence. That was true for the classical Maya in Mexico, and it was true for the Nez Percé in the Pacific Northwest. Unsettled wilderness has always been a recognized part of the American landscape, and thus protected wilderness areas today are, in many respects, a natural outgrowth of a concept and condition that was common long before Europeans arrived in America.

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SMALL WORLD

In Search of the Chaplet of Flowers

By Rob Nicholson

When we looked well at all of this, we went to the orchard and garden, which was such a wonderful thing to see and walk in, that I was never tired of looking at the diversity of trees, and noting the scent which each one had, and the paths full of roses and flowers, and the many fruit trees and native roses, and the pond full of fresh water.... I say again that I stood looking at it and thought that never in the world would there be discovered other lands such as these ... Of all these wonders that I then beheld, today all is overthrown and lost, nothing left standing.

—Bernal Diaz (1568)

Anyone who has ever labored to create and maintain a garden, especially on a large scale, knows too well how last year's vision can succumb to cold and drought or become an unimagined rampant tangle. Every profession carries a deep fascination for its own past, but some trades bear the ravages of time more notably than others. Architects, potters, and sculptors probably fare the best, with the products of their imaginations enduring long after their creators are returned to dust. How few gardens there are of great age, and fewer still, ruins that can be recognized as gardens. The gardener's lot is to dodge between the seasons, collecting daily pleasures, with scant chance for the admiration of future generations. But few of us who garden have had to let their gardens endure a clash of worlds, with one culture intent on destroying the monuments, religion, culture, and creative products of another.

The epigraph above is by from a scarred veteran, Bernal Diaz, who served in the army of Hernán Cortés, the force that brought down the Aztec empire. In his memoir *Historia verdadera de la conquista de la Nueva España* (*The True History of the Conquest of New Spain*) he reflected on the magnificent gardens they discovered. The diversity of the gardens reflected the vast flora of Mexico coupled with the rulers' obsession with plants, and their scale, design, and beauty stunned and beguiled the conquistadors.

On a hill at the edge of the metropolis of modern Mexico City stand the ruins of one such garden, now 500 years old. It was the "stately-pleasure dome" of the Texcocan *tlatoani* or king Nezahualcoyotl (1402–1472), the final retreat from the wars, exiles, and court intrigues of his life. A place of poetry and refuge in its heyday, it is possibly the oldest and

On the site of Nezahualcoyotl's gardens just outside modern Mexico City, the view from this small, duct-fed pool takes in the heart of the Aztec world (page 38). *Photograph by Leo Crespo-Herrera*

best-preserved Pre-Columbian garden site in the New World, and perhaps the oldest botanic garden in North America.

Being in southern Mexico to collect plant specimens in the state of Oaxaca in the late summer of 1998, I decided to end that trip by visiting the ruins at Tezcotzingo. After flying into the Mexico City airport, I rented a car and began the drive to the outlying town of Texcoco, site of the garden's ruins. The day's journey began in an inauspicious manner as not only was traffic fast and furious, but within the first ten minutes of driving I was twice pulled over by Mexican police for phantom "violations" requiring, after long debates, the fines of instant justice.

I poked along through local traffic, occasionally stopping to get directions. Texcoco has a large agricultural college, and here I was given precise directions to the site. From the college I began to drive upward, off the fertile, ancient lake bed into the dry scrub of opuntia cactus and mesquite trees. The ruins are now part of the Zona Arqueológica Tetzcotzinco (INAM) and the small quiet village of Molino De Las Flores rests near the foot of the regal retreat. Here I parked just as a party of Americans, including Cornell-trained horticulturist Paul Avilés, came down the path. Their effusive excitement erased the tension of the morning's drive. Paul would go on to write one of the definitive papers on the ruin, cited below, which maps out the multi-faceted complexity of the site.

A path took me past the ragged farmscape of the town's outskirts, burros clanging bells and neighing horses acting as sentries. Shaggy opuntia trees and spiky agaves hardly conjured up images of the lush gardens of centuries past. Walls and steps led upward, some of these recently repaired by INAM. The path doubled backward and became sharply steeper. About a third of a way up the hill came the day's first revelation: on a forty-foot-wide patio was 14-foot-wide pool some five feet deep; plants in large terra-cotta pots could easily be imagined decorating the plaza. Stairs carved of solid rock led down into the pool, while slabs of stone with carved channels down their middles led the water into the pool.

Much of what we know of Nezahualcoyotl's life and works comes from Fernando de Alba Ixtlilxochitl, a Catholic partial descendant of the king's clan, who was an early chronicler of the regent's history and

Much of what we know of Nezahualcoyotl's life and works comes from Fernando de Alba Ixtlilxochitl, a Catholic partial descendant of the king's clan.

Depiction of Nezahualcoyotl in the Codex Ixtilxochitl (ca. 1580–84), one of the important post-conquest sources of Aztec politics and culture. (1550) Codex Ixtlilxochitl. *Retrieved from the Library of Congress, https://www.loc.gov/item/2021668123/*

Top, stairs to the sanctuary and, bottom, pathways in the King's garden as they appear today (page 42). *Photographs by Leo Crespo-Herrera*

A large pool, with its single remaining frog figure, suggests the extensive irrigation and hydraulic systems that would have supported Nezahualcoyotl's garden in its heyday. *Photograph by Leo Crespo-Herrera*

world. While historians debate the influence of the Church on his writings and perhaps his own desire to enhance his clan's reputation, his account gives details found nowhere else. He related that three frog statues, perhaps symbolizing the Triple Alliance, once were stationed on the edge of the pool, and the remnants of one is still visible. Precious little additional figural work from the garden remains, though the National Museum of Anthropology holds a monkey-faced, open-mouthed gargoyle pulled from Texcotzingo, where water once gushed from its mouth, no doubt to the amusement of children.

Was the pool constructed for religious significance, or was it simply for bathing and basking, a precursor to Hollywood hot-tub hedonism by 500 years?

However sybaritic his pursuits at the height of his power might seem to have been, it was not hedonism that set Nezahualcoyotl on his path to greatness. At the age of 15, in 1418, the young Texcocan prince experienced an invasion of the kingdom of Texcoco by the neighboring Tepanacs. Hiding in a tree, he witnessed the assassination of his father, the king. Nezahualcoyotl escaped, was captured, escaped again, and began a period of exile and subterfuge. In time the Tepanacs, under the regent Maxtla, bled their subjects to the point of revolt. After enlisting the aid of Tenochtitlán, the neighboring power in the valley, Nezahualcoyotl returned from exile to lead an uprising, reclaiming the Texcocan capital and vanquishing Maxtla.

This sequence of events helped forge what came to be known as the Triple Alliance, uniting in purpose the two large kingdoms of Texcoco and Tenochtitlán, along with the smaller Tlacopan. We generally think of this triple alliance as the Aztec kingdom. These three states combined to dominate the Central Mexican plateau for the next century and spread their influence and dominion 600 miles to the south.

The early historian of the Spanish invasions of Mexico and Peru, William Hickling Prescott, included many details about Nezahualcoyotl and Texcotzingo in his classic *"The History of the Conquest of Mexico"*(1843). He related that within his kingdom, Nezahualcoyotl solidified his rule with a code of 80 laws, including one regulating the cutting of forests (this may be the first conservation law enacted in the New World). He divided the government into four councils, those of war, finance, justice, and of music. This latter council was responsible for the pursuit of astronomy, biology, botany, and the arts of music, dance, poetry, painting, weaving, and featherwork.

The Aztec kingdom was established on a high lakebed ringed by hills and mountains. Tenochtitlán and Tlacopan were on the western edge, while

Digital rendering looking east-northeast across the Basin of Mexico around the time of Nezahualcoyotl. Tenochtitlán lies in foreground, its ritual districts glittering, Texcotzingo on the far side of the lake (in yellow frame). *From* A Portrait of Tenochtitlan *by Thomas Kole, https://tenochtitlan.thomaskole.nl/, CC-BY 4.0*

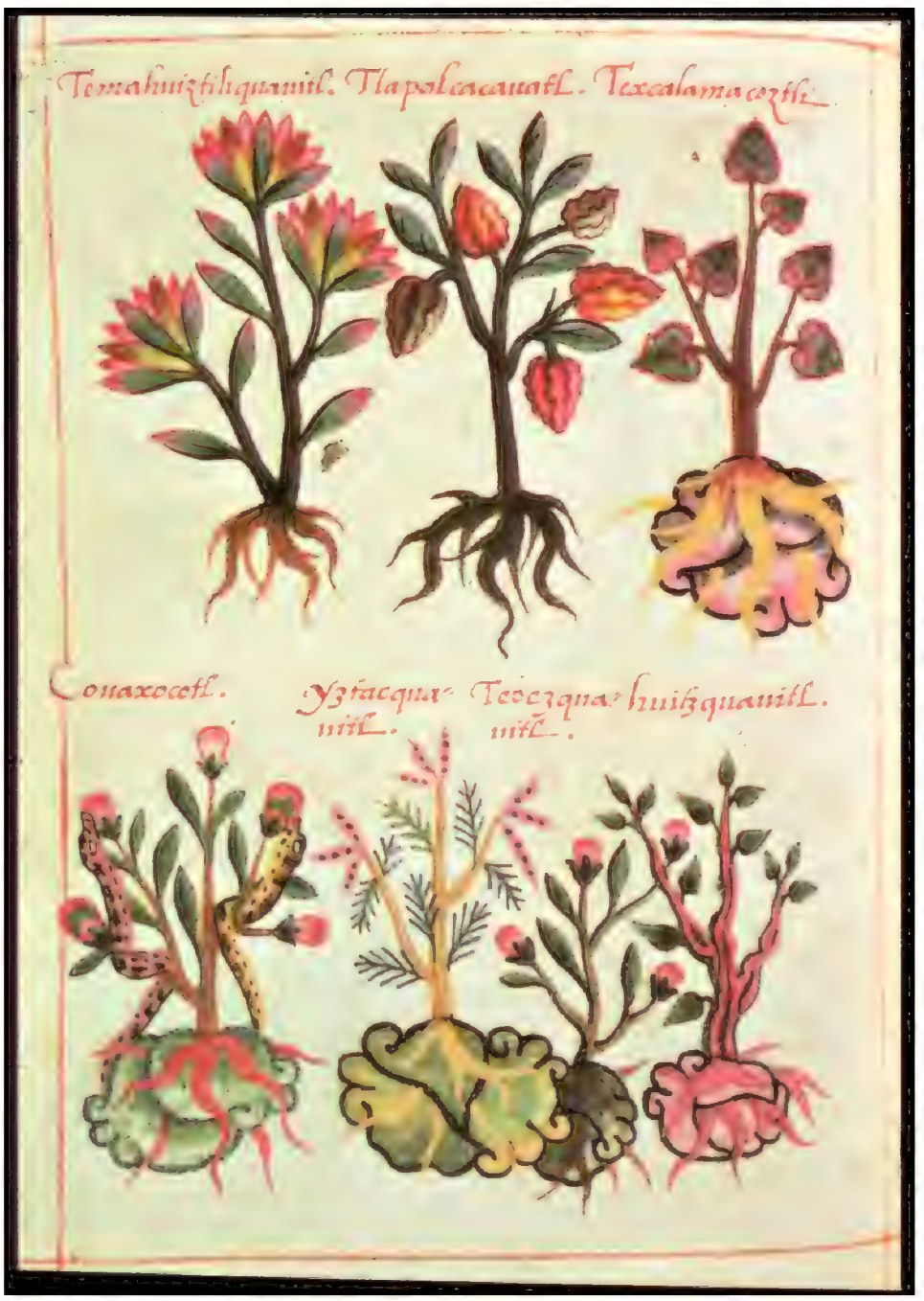
Texcoco occupied the east. Water management by means of dikes and aqueducts was crucial, and Nezahualcoyotl became an adept engineer during his exile in Tenochtitlán. Rising off the level plain of the ancient lake bed, a gradual incline steepens into a series of hills and mountains. Nezahualcoyotl sited his rural retreat on a cone-shaped peak in this transition zone. He and his subjects transformed this small mountain into a magnificent garden, Texcotzingo, a refuge suffused with many layers of meaning, symbolism, and purpose.

His skill as an engineer was honed when he designed various dike and canal works within the Three Kingdoms, while his aesthetic sense had been refined by the artistry produced by his Council of Music. These were brought to bear on the design and execution of this early North American botanic garden.

Evans, cited below, compiled a listing of 20 pleasure gardens, zoos, aviaries, game preserves and medicinal plant gardens of the Aztec kingdom. Chapultepec, the major pleasure garden of the Tenochtitlán elite, is where Nezahualcoyotl reputedly designed the aqueduct and tree plantings. It is now a major urban park of Mexico City. Huaxtepec, was built during the rule of Tenochtitlán emporer Moctezuma I (1398–1469), was located 60 miles southeast of Tenochtitlán, and at an altitude 3000 feet lower in a milder, more tropical climate. This allowed for the cultivation of tropical rarities like *Chiranthodendron pentadactylon,* the hand flower tree, and other tender plants. Moctezuma requested plants from the lowlands from the Lord of Cuetlaxtla (now Veracruz on the Gulf coast) be transported to this garden which, like the contemporaneous Texcotzingo, were also tied to religious worship and symbolism. This garden, from a horticultural standpoint in a different "hardiness zone," may stand as the first amassment of tropical plants in the New World. (For a fuller description of this garden, see Granziera, cited below).

The ruins of Texcotzingo, sadly, are among the few vestiges of this passion for large scale gardens. The royal villa was positioned at the base of a hill in the grove of giant ahuehuetl trees, *Taxodium mucronulatum*. Davidila Padilla, in 1596, reported trees at this site with 90-foot trunks with a four-foot diameter.

To this dry site, Nezahualcoyotl brought the cool water of Mt. Tlaloc, carried for five miles by an aqueduct, portions of which still stand today. His design would have required a small army of laborers and slaves to build it, managed by a cadre of experienced engineers, overseers, soldiers, and skilled workers. The aqueduct joined the hill about two thirds of the



The first known depiction of *Theobroma cacao* (top center), the source of chocolate, in the *Libellus de medicinalibus Indorum herbis* of Martín de la Cruz, also known as the Badianus manuscript (1552). *Courtesy, Digital Images and Slides Collection, Fine Arts Library, Harvard University*

way up, and a system of canals and pipes distributed the water to numerous pools and cisterns or released it at various points to tumble and mist over the cliffs and rocks. With the main problem of irrigation solved, plants adapted to moister and cooler climes could be nestled into appropriate, artificial microclimates. No planting plan or list exists today of course, nor is it safe to assume that those plants presently growing at the site, lovely as they may be, seeded themselves from Nezahualcoyotl's original plantings.

The King's love of plants and nature manifested itself in reports of his collection of botanical illustrations. Some of these were illustrations on the paper material that was made from āmatl bark (a *Ficus* species) or from the fibers of Agave. The Codex Mendoza is an account of the tribute lists the Triple Alliance extracted from subjugated regions on a regular basis and paper was one of the many items demanded from particular regions.

Nezahualcoyotl had an extensive library, including botanical depictions. Alexander von Humbolt, in his book *Cosmos,* recorded that copies of these made their way to Francisco Hernández de Toledo, the private physician of Philip II of Spain. He had been sent to Mexico to document the flora and fauna, and his encyclopedia is one of the first post-conquest books to feature depictions of Mexican natural history. None of the plates of Nezahualcoyotl's collection are known to survive today, and pre-conquest works on paper are exceedingly rare, few having survived the fires of the Spanish purging. Other botanical depictions, painted on the walls of his residence, were of tropical plants he could not grow in the high Central Valley. These frescos, botanical artworks, and gardens are all now eradicated and lost.

The Badianus Manuscript/Codex Badiano (1552), an illustrated Aztec herbal produced 30 years after the fall of Tenochtitlán under the eyes of Catholic clergy (hence no religious references), contains 182 color illustrations made by an unknown artist of Aztec descent. It gives us some idea of the style and symbolism of Aztec botanical illustration, and may

Nezahualcoyotl and his allies competed botanically with each other through their collections of living plants.

be similar to what Nezahualcoyotl contemplated in his portfolios and on his walls. It includes the oldest depictions of New World *Magnolia, Pinus, Cupressus, Abies,* and *Theobroma,* along with many other plant varieties of medicinal, culinary, and ritual import. But with so little to compare it with, we have no way of knowing if this trove of images is a standardized set of depictions or a single artist's wondrous interpretation.

Nezahualcoyotl and his allies competed botanically with each other through their collections of living plants. In their extensive gardens, nurseries, game preserves, and retreats, they incorporated plant material transported from throughout their domain, and gardeners knowledgeable about their culture were often pulled to the cities with the plants. Much as the grand conservatories of Europe in the 1800s displayed flora from their colonies, Texcotzingo may have had plants bedded from various vassal states, a living display of empire and control. Perhaps the most compelling evidence of this obsessive horticultural rivalry was detailed by De Torquemada in his historical tome of 1615, *Monarquía Indiana*. Moctezuma II invaded the bordering Mixtec kingdom after the Lord of Tlachquiauhco, Malinal, refused to part with a particularly rare tree, known as the red-flowered popcorn tree (*tlapalizquixochitli,* probably a species of *Bourreria*) and caustically insulted Moctezuma's emissaries in the process. This affront may have provided a gambit to justify an invasion, or perhaps he sincerely coveted an additional rarity. After the usual slaughter, he added the tree to his garden, a serious gardener indeed. (See Nicholson, cited below).

Some of these gardens, such as Calpulalpan, specialized in medicinal plants, possibly indicating a split between science and pleasure grounds. Given the more refined reputation of the Texcocan court as compared to Tenochtitlán, we might expect a greater sensitivity to ornamental plant material, its cultivation, and its placement in a well-designed landscape.

If Diaz related 450 years ago that *"today all is overthrown and lost"* with respect to all of these

resplendent gardens, what more could I possibly hope to find? I continued upward, passing another small pool, this one carved into the solid stone of the cliff side. Was it just big enough for one—a solitary poet's musing spot—or did it hold clusters of children under a watchful governess's eye? Possibly it contained water plants such as the Mexican water-lily, *Nelumbo mexicana,* grown in a tub the way many water-lily fanciers do today.

Two step-sided niches were carved into a wall behind the pool, and it was easy to imagine potted plants in each, or fresh bouquets of flowers picked early that morning prior to the king's soak. That the Aztecs only had soft metals like gold, silver, and copper, makes these rock carvings astounding. A series of steep steps carved into the cliff side led down to a small plaza, perhaps a small intimate space for family meals under a tent or for smaller scale entertainments. The path leveled out and bent with slight s-curves, following every modern gardening dictum against straight paths. The inside of each curve formed a natural planting area. Were echeverias, salvias, marigolds or any of a hundred Mexican ornamentals planted here for scent and display?

The garden was designed as a series of plazas, patios, manicured overlooks, and hidden beauty spots all connected by a series of paths. It is reminiscent of the "circuit gardens" of the Feudal Japanese nobility where one "takes a journey" within a garden. The ascent began in a planted forest (wilderness?) of *Taxodium* at the bottom and proceeded to a temple and statuary depicting his life at the top, perhaps symbolic of the regent's own struggles and life's journey.

Next to one section of path ran an above ground aqueduct ran, two low walls a foot wide containing a sluice of water. It was remarkably similar to Persian garden design, the gardens of another arid zone, where the sound and sight of water cool the psyche.

Toward the back side of the mountain was a point where the main aqueduct ended its five-mile journey from the mountains, carrying water on the top of large embankments, some 150 feet high. It crossed a final small valley, and brought forth its nourishing water. In the fields of the small farms below, a sombreroed man in a bright yellow shirt slowly pecked at weeds in the dusty brown rows of soil.

A seventy-five-foot square plaza looked eastward towards receding sheets of mountains. At one end was a set of terraces and a cave carved out of stone. Caves had specific religious meaning to the Aztecs and it seemed to retain its seriousness of purpose as there were recent offerings of flowers in gallon tin cans and ears of corn. The largest level area upon the mountain, this was likely a place for ceremony, oratory, and the entertainments of song, poetry, and dance.

Stairs rise from this plaza to the mountain's peak, where Ixtlilxochitl states that Nezahualcoyotl built a temple, its first nine stories to represent the Nine Heavens. A tenth and final story was topped by a roof painted black, and profusely gilded with stars on the exterior with inlaid metals and precious stones on the interior. The King dedicated this to "the unknown God, the Cause of causes" a monotheistic supreme being that he had come to believe in.

Accounts describe a statue of a canine at the crest of the mountain, carved with Nezahualcoyotl's face, likely a gift to his descendants. Nezahualcoyotl's name itself translates to "Hungry (or) Fasting Coyote," so the obvious symbolism may be a declaration of final victory, triumph over his early history of family murder and exile. The statue was destroyed early on by the Spanish, the Bishop Don Juan de Zumárraga having purged it and many other sculptures on the mountain as symbols of idolatry. Not only was the invasion by the Spanish a martial invasion but a spiritual conquest as well.

Coming to the crest of the summit, none of this art and architecture could be seen or even imagined. Only a pile of rubble with a broken concrete crucifix hinted at worship of any stripe. Amid the tumble of boulders were evergreen oaks, three-foot shrubs of *Echevaria* and the beautiful blooms of *Sprekelia formosissima,* a bulbous plant of the Amaryllis family. The bright cardinal-red flowers with five strap-like petals seemed an aerial dance of color, a tangle of brushstrokes floating in space. Who can imagine what wonders of the plant world were once tended here? What glorious birds came to visit? What poet's song graced the dusk?

Evidence suggests a vast collection of living plants were kept here; touring the site, I could see how they might have been planted and nurtured here. We know Nezahualcoyotl was learned in plant life, too. Do these elements make Textcotzingo a botanical garden? If so, with its dedication in 1467, it would be the remnant of the oldest botanic garden in the world. It was described as such by Zelia Nuttall (1857–1933), an American archaeologist and anthropologist specializing in pre-conquest Mexican cultures, who was perhaps the first to refer to these ancient Aztec

Examples of pre-conquest botanical imagery in Aztec visual culture survive in objects like this bowl from Azcapotzalco. Restored floral painted light pottery tripod dish, Object Number 35-106-20/10950, 11 × 22.5 cm. *Peabody Museum of Archaeology and Ethnology, Harvard University*

At the summit of Nezahualcoyotl's mountain site, *Sprekelia formosissima* in bloom. *Photograph by the author*

gardens as "botanical gardens," in English, in 1923.

Given an incredible palette of 26,000 Mexican plant species and the regent's imperative of beauty and rarity, it becomes an enjoyable intellectual exercise to imagine which botanical wonders were included. Which senses were prioritized? Which colors? Which scents? As Granziera documents, specific flowers were associated with the gods and goddesses of the diverse Aztec pantheon; did religious connotations impact the plant choices and designs? Nezahualcoyotl dedicated the site to Tláloc, the god of rain and fertility, so it is probable that this deity's flower, *Tagetes lucida,* the hallucinogenic Mexican mint marigold was heavily planted. Of the hundreds of Mexican *Salvia* spp., ranging from compact shrubs to 10-foot giants, with a choice of all flower colors but green, did Nezahualcoyotl favor certain species? Did he delight in watching hummingbirds battle over their blooms? What bulbs were nestled in crevices—rainlilies (*Zephyranthes*), clown flowers (*Tigridia*), spider lilies (*Hymenocallis*), Aztec lilies (*Sprekelia*), the charming and elegant coral drops (*Bessera elegans*), or mariposas (*Calochortus*)? What Mexican species of current garden-center favorites were cultivated here 500 years ago—begonias, marigolds, dahlias, lantanas, plumerias, portulacas, daturas? Given the worldwide fascination with cactus and succulents, it would seem logical that large candelabra cacti and dramatic agaves, as wells as sprawling sedums and pincushion cacti, playfully punctuated the slopes, much as Mexican landscape architects use them today. What species of conifers were chosen? How many of the 43 Mexican species of *Pinus* made the cut? Did the intoxicating scents of the medicinal yolloxochitl (*Magnolia mexicana*) or eloxochitl (*Magnolia macrophylla* subsp. *dealbata*) waft among the paths and plazas? Were the gardeners selecting and propagating different strains of *Rosa montezumae,* being the earliest "rose fanciers" in North America? What modern landscape architect wouldn't dream of recreating the plantings?

A floristic inventory of the mountain conducted by Pudilo and Koch in 1988 showed a surprisingly high level of diversity over its the 50-hectare extent, with 375 species, 234 genera, and 70 families of vascular plants. They cite a few species that seem out of place for this region (*Thevetia peruviana*), and they detail a number of rare species, such as Harrison's spider lily (*Hymenocallis harrisoniana*) and a cotton relative, *Malaviscus arboreus*. But they also list "garden variety" genera such as *Dahlia, Salvia, Sedum*, and *Opuntia*.

While the plants presently on the mountain may or may not be direct descendants of those put in place by Nezahualcoyotl's gardeners, the remarkable hardscape endures. One suspects that additional wonders lie buried throughout the hill and the state department of archeology, INAM, is slowly working to uncover the ruin.

If you apply the modern definition (IUCN 1989) of botanic garden—"a garden containing scientifically ordered and maintained collections of plants, usually documented and labeled, and open to the public for purposes of recreation, education, and research"—then it is a pretty loose fit. (In 2018, Botanic Gardens Conservation International updated its own definition to include "conserving rare and threatened plants, compliance with international policies, and sustainability and ethical initiatives.") But then, what are considered the earliest European botanic gardens, Pisa (1544) and Padua (1545), probably wouldn't qualify either, let alone dozens of modern US gardens that label themselves botanic gardens.

But perhaps the category itself is too wide to apply to the site, or others like it in Mesoamerica and beyond. In his seminal paper on Texcotzingo, "Seven Ways of Looking at a Mountain," Paul Avilés, the horticulturist and scholar I met at the entrance to the site in 1998, advises against the temptation to pigeon-hole them into our definitions. "Even if Aztec gardens do satisfy most of the European criteria for what constitutes a botanical garden," he writes, "an attempt to retrofit them to Western categories qualifies as a rather blatant bit of contemporary cultural colonialism." He continues:

> [F]orcing these indigenous artifacts into decidedly non-Aztec definitions and paradigms skews and constricts, contorts and falsifies both our understanding and our experience of these spaces, and in the process, such a move also distorts their meaning. By broadening the questions, however, we can begin to consider a space like Tetzcotzingo on its own terms, without reference to the European tradition and as the product of a complex garden-making culture worthy of serious and sustained study.

Our human concept of "botanic garden" has been ever evolving and continues to change, drastically in just my lifetime. Notably, the 1989 definition does not include the term "conservation," now a major focus. As Granziera points out, the worldview of plants by the Aztecs by contrast was saturated with religious beliefs and connections. Unlike current botanic

gardens, these Aztec gardens were planted with worship, more than science, in mind. But for this botanist (and possible cultural colonialist!), if you know the site's history, the Aztec rulers' passion for plants, visit it, and work your imagination hard, "botanic garden" seems rightly applied.

I started my downward passage, retracing my steps and getting a final look at the marvelous ruins. At the large pool, two Mexican teenagers sat atop a wall obliviously in love, perhaps like lucky couples five centuries earlier. Looking out into the valley from the patio of a once-mighty king, they could only hear the future of their own heartbeats. I passed quietly by, grateful to have had my botanical boundaries pushed in new directions, and with dozens of questions needing further study. If nothing else, Texcotzingo, the haunting ruin of an once paradisical garden, compels you to *discover,* while there and afterward.

The early historian of the Spanish invasions of Mexico and Peru, William Hickling Prescott, included many details about Nezahualcoyotl and Texcotzingo in his classic *The History of the Conquest of Mexico* (1843). He pulled much of his information from Fernando de Alba Ixtlilxochitl's work but recognized there was "double filtration" in that there was a translation from Nahua to Castillian and then Castillian to English.

Nevertheless, he offered this poignant translation from one of Nezahualcoyotl's poems.

> ... Then weave the chaplet of Flowers,
> And sing thy songs in praise of the all-powerful God;
> For the glory of this world soon fadeth away.
> Rejoice in the green freshness of thy spring
> For the day shall come when thou shalt sigh for these joys in vain ...

Nezahualcoyotl, 1402–1472, preserver of forests and lover of plants, left for us in his poetry a succinct warning, which seems so apt in our era of climatic and ecological turmoil. We might do well to listen.

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VISUAL ESSAY

Trees, Vessels, Trails

By Kyle Browne

Site-specific art, specifically work made in relationship with the natural world, has been a practice that cultivates a deep remembering. It beckons me to get in touch with a "consciousness of place"—a site's essence, or spirit, which is informed by historic ecological, social, and energetic narratives—most which are subtle and in need of unearthing.

My research takes the form of private performance in collaboration with site, laying a foundation for the creation of meaning in the ensuing body of visual work. During one residency, I hiked along the ridge of a caldera in East Oregon, charred and felled trees from a recent fire lying in all directions. The devastation caught me off guard, as I was expecting a lush forest. I spent days walking, observing, and crawling through the vacant insides of large trunks, discovering their hollowness. I dressed in black and stood like an ally, unwavering, next to the burnt pillars. I laid on the ground between severed trees trying to sense the threads of energy that may still exist, channeling my own to connect two disparate limbs. Archaeologist Julian Thomas has defined "corporeal knowledge" as "the way in which we know the world... based upon our immersion in it.... the body is not a container that we live in, it is an aspect of the self which we live through." The surfaces of our bodies, the ecotone between interior and exterior, is the key to one's own authentic knowing. I believe my practice of experiential embodiment with nature is a tuning into an ancient wisdom that many of us have unconsciously forgotten.

The natural world has been my teacher since I was a small child, growing up on the ebb and flow of the tides in a small fishing town north of Boston. It was in that place that I learned to listen to the imperceptible, relish in wonder, and respect the difference between what I did and did not have control over. Working with natural materials reiterates that for me. One must allow the material to show you how it wants to bend, break or coalesce. The challenge and richness is in the collaboration, reflecting a spiritual foundation of mindfulness, where presence and detachment is essential.

Increasingly, my spiritual practice has influenced my relationship with art-making. I've incorporated the importance of ritual to understand the cycles of the natural world and incite reverence into sensory, tactile and material explorations. This intentionality—engaging in a moment of presence or gratitude before working with a site or its materials, for instance—helps me center into the process, and be open to the intangible as valid and authentic. It is an invitation to go beyond the favored, logical way of knowing and to let more subtle pathways of discovery and collective knowledge open. The final visual expression and culmination of my artistic research has many rich layers that are barely perceptible; however, I hope it sparks a feeling of wonder and curiosity, that allows others to encounter the enigma of place and their interconnected relationship with it.

The images I share here span over ten years of site-specific work. They include places I've had the opportunity to collaborate with short-term and long-term through artist residencies, and places near where I have lived.

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facing page:
Qi of MARS (Manship Artists Residency)
Detail and in-process
Plaster, acrylic paint, sealant, metal flake, natural objects
2023

facing page:
Birch Bark Portals
Installation Process + Material Exploration
Birch bark, twine
Wild River-White Mountain National Forest
2013

In residency in the White Mountains National Forest for three weeks in the summer of 2015, invited to stay in rangers' houses, I camped when I could in the wilderness, trying to find the most remote places. A unique aspect of that summer is that the forest was recovering from a very damaging winter, which created many areas of large debris build-up and erosion. I spent five nights camping alone by the Wild River, collecting, exploring materials by fire light, and searching for a site to install my work. Installing work in nature is intimidating because the art is always dwarfed by nature's expansiveness. Along the trail, I found many dead birch bark limbs which I began investigating and accumulating into rings. I was fascinated with how, once hollowed, they served as frames and viewfinders, helping me to perceive the forest and river in new ways. I created "Birch Bark Portals" with that inspiration. Looking through each circle is unique, with the added intrigue of movement— it is a kinetic sculpture that turns with the wind or the flow of the river. It was installed in a place with low human traffic, but near a site of high damage. My hope was that the curious hiker who appreciates wildness and introspection would stop and experience the environment from a different perspective.

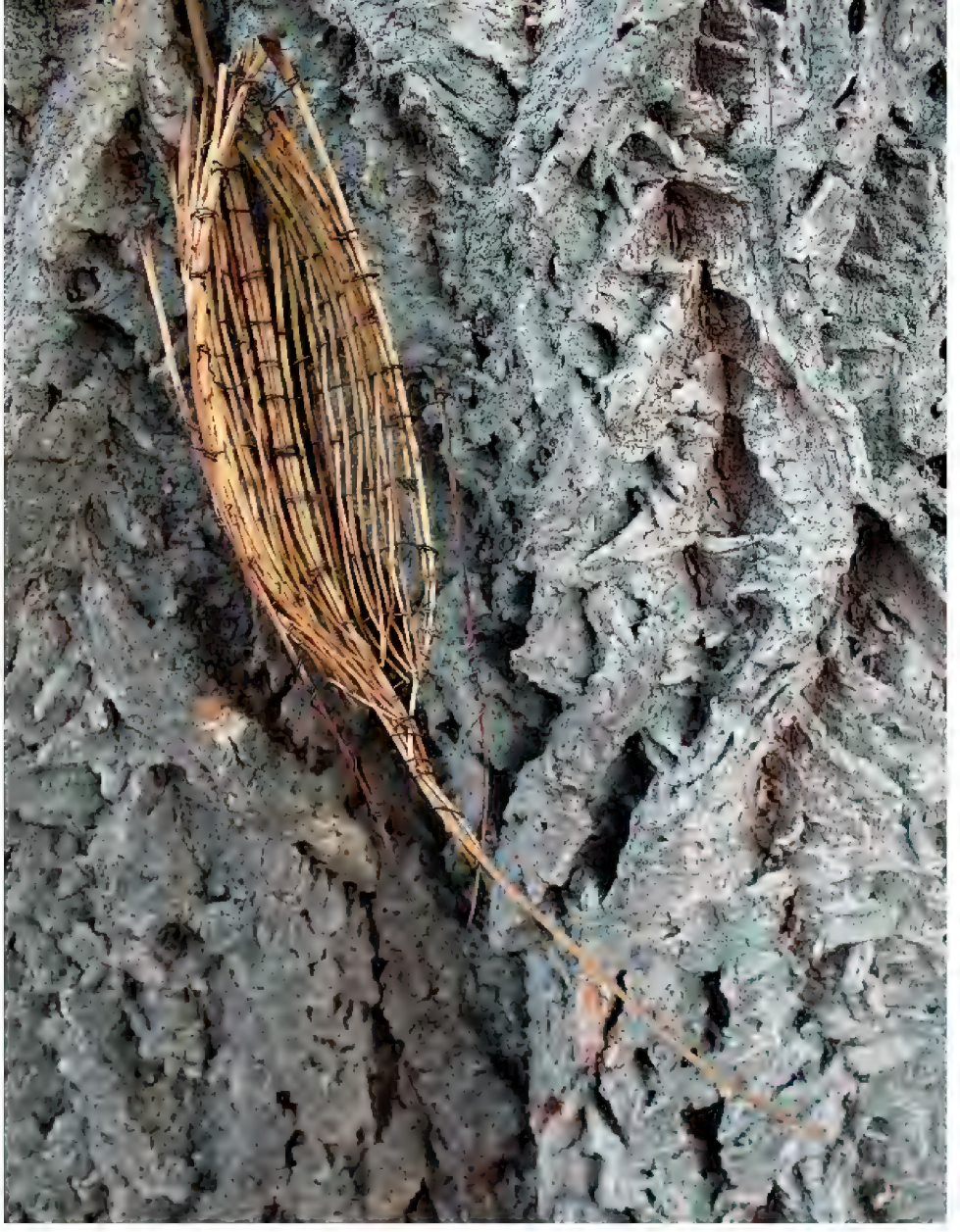
above:
Still from Artistic Research at Caldera Artist Residency
Deschutes National Forest
Deschutes, OR
2015

Here I am engaged in performative artistic research, lying in a human-made cut in a felled tree. To become part of it, I tried to place my body in a way that aligned with the tree's negative space. I was curious what happens to the life force in trees after they die, and whether I could be a conduit for any remaining life between the amputated limbs. The forest was completely devastated by a forest fire two years earlier, and so much death still surrounded me. Yet, I knew this was part of a cycle, that it would regenerate in time. This process helped me connect with the forest, giving my life force towards its regeneration while contemplating humanity's part in this destruction.

facing page:
Artistic Research at Caldera Artist Residency
Deschutes National Forest
Deschutes, OR
Charcoal on found tree
2015

above:
Beetle Graffiti
Deschutes National Forest
Deschutes, OR
Charcoal on Paper
2015

During this residency I became fascinated with beetle borer trails. Because of the forest fire, there were many trees without bark, exposing their inner surfaces. I began noticing the intricate workings of lines interwoven in many dead trees. Drawing is a foundational practice for me, so this mark-making excited me. In response to the charred forest, I worked with burnt wood—charcoal—to outline and accentuate these found drawings. By sheer accident, I discovered a way to create prints onto paper with direct impressions from the trees. This also inspired me to investigate the living creatures themselves, the beetles. I discovered that they, just as much as the fire, had likely killed the trees. I also found out that each burrowing line records the beetle's life cycle from birth to death. I began looking at these lines as traces that tell a unique narrative of a creature's journey. The final series, Beetle Borer Prints, is an accumulation of these intriguing miniature maps and stories. The image on the (above), titled *Beetle Graffiti*, is a layering of multiple beetle borer trails, reminiscent of graffiti, a style of visual communication.



above and facing page:
Cork Tree Vessels
Arnold Arboretum
Jamaica Plain, MA
Cork tree stems, garden wire
2016

As part of my graduate research, I chose to investigate the abandoned Franklin Bear Cages in Boston's Franklin Park. This led me down a very interesting historic and geographic rabbit hole, learning about the park's designer, Fredrick Law Olmsted, polar bears, and zoos. I began building vessels to interact with the site and the pools of water in the now-vacant holes at the bear cages, providing a symbolic way to bridge many different histories and imagined worlds. I had already created a larger vessel and wanted to experiment with smaller, more intimate structures. After looking at the construction of boats on lakes in Peru including indigenous practices, I set out to find materials. It was autumn and trees were shedding their leaves. Under a massive cork tree (*Phellodendron amurense*) in the Arnold Arboretum, I was privileged to discover multitudes of delicate stems (the petioles and rachises of the compound leaves). I collected many of them and began my material exploration. I loved bunching and twisting them into shape, bending them while they were wet to see how they would hold, allowing them to direct the structure, in an immense process of failure and discovery. The final pieces comprised a wide range of forms, reminiscent of antique snowshoes, viking ships, and seed pods. The cork tree itself has magnificent, undulating bark, rippled like waves in the ocean. The final, in-situ photo shoot documented the vessels traversing its surface.

above:
Still from Artistic Research at Manship Artist Residency
Gloucester, MA
Quarry reeds, wire, cardboard
2023
Photo (above) by Gareth Greenville

An unexpected outcome of my time in the Manship Artists Residency was a live performance. As part of the artistic research for a commissioned installation, I created 'sensing' devices to help me channel energy and find magic. One of my daily meditations was to paddle or swim the quarry where I enjoyed the colorful lily pads and subtle sounds of swaying quarry reeds. Quarry reeds with their tall stature and fluffy flora were an ideal fit to build a sensing device for my head, since the crown chakra is the strongest place I connect with external energy. What I didn't realize is that when I adorned it, I would begin to feel the subtlest shifts in wind and embody the plant itself. This experience led me to collaborate with a co-resident, jazz musician Stan Strickland, to create an intuitive performance with the quarry. *Spirit Sensing: Anima of the Quarry* was performed for a live audience in October 2023, and is now a short film about to embark on a one-year film tour. This image shows me wearing the sensing devices at Starfield, the property of the Manship, the name of which is inspired by the fireflies that gather there seasonally.

facing page:
Still from Spirit Sensing: Anima of the Quarry
Live performance
Gloucester, MA
2023
Photo by Darlene DeVita

Propagations

FERAL ECOLOGY

Arboreal Soundscapes

By Jacek Smolicki

During my inaugural spring soundwalk through the Arnold Arboretum in early April 2023, I spent a significant amount of time with an eastern white pine. The tree stands with no immediate neighbors, in close vicinity to a rippling brook below, next to the foot of a little hill where other trees, with the help of a human hand, form a more dense ecosystem.

I walk slowly towards the trunk, stepping carefully in the gaps of the tree's partly revealed root system. Predictably, most of the roots stretch directly towards the water. After sitting by the tree and listening to the surrounding soundscape, I open my backpack and pull out two hydrophones. These are special microphones that bioacousticians, environmentalists, sound artists, and scholars across the world use to listen to and assess the quality of underwater environments. The hydrophones I use in my work can also serve as contact microphones. By attaching them to a solid surface of almost any object, contact microphones sense the vibrations that propagate through it. Unlike traditional microphones, they are almost entirely insensitive to airborne waves, instead providing the listener with access to another, often imperceptible or overlooked, yet fundamental dimension of the space around us, namely its continuous vibration.

As a sound artist and scholar interested in the multifaceted and multitemporal nature of our landscapes and soundscapes, I use such microphones for various purposes. I have deployed them in urban contexts to listen to vibrating elements of urban infrastructure: bridges, radio, mobile network towers, and banisters. In parks and forests, I have been using the same devices to attune with inner soundscapes of tree trunks and nurse logs orchestrated by the vibrant life patterns of beetle larvae and other insects. I have also used such microphones to shift my listening position, letting the trees guide my perception of the forest or a city. Attaching the microphones to tree trunks or their branches temporarily turns them into extensions of my senses, allowing me, and those who join my soundwalks, to sonically connect with the surrounding ecosystems. In enabling various elements of the environment to mediate its soundscapes, one quickly becomes aware of the unbearable degree of anthropogenic noise that fills and pollutes our natural and urban habitats.

After gently positioning my hydrophones next to the eastern white pine's roots—I carefully adjust the levels on the interface of my audio recorder. Soon, an unusual amalgam of sounds reaches my ear. I can hear the traffic din from the nearby road. I hear the wind above gently brushing the tree branches. I can hear occasional clicks and pulses of the roots pumping the water from the brook nearby. In the background, I can detect the rushing water of the brook itself. The longer I listen, the more my sense of the present moment dissolves. Significantly augmented by my sound equipment, my attention is at once grounded and distributed across multiple dimensions.

Aural attention to this constellation of sounds can teach us several things. Firstly, that sounds are always relational events: the sound we hear at any given moment never entirely belongs to one or another entity or object, but emerges from an interaction of diverse forces and materialities, through time and space. In modern societies, we have been trained to divide our senses, to dissect and isolate diverse phenomena from their spatial and temporal contexts in order to understand them better. The development of scientific instruments operating within the boundaries of individual senses—optical or acoustic, for example—has only increased our tendency to see and hear things as independent and hence easily categorizable, indexable, and controllable. In my work, I try to advocate

Illustration by Veronyka Jelinek

for listening—both unaugmented and aided by microphones and other technologies—as a practice of attention to connections that underlie our experience of the surrounding space. Surely, many technologies I and other field recordists use in their work historically stem from the lineage of scientific instruments of colonial expansion and control, geared towards collecting traces of other cultures and environments. While acknowledging this fact, my approach resonates with that of anthropologist Anna Lowenhaupt Tsing, who suggests a burning need for rethinking the role of technologies in the times of Anthropocene. She asks how technologies can be decoupled from problematic motivations that steered their development, to instead help to reveal the realms that modernity has over the course of centuries ignored and damaged. Artistic practice, she argues, is one territory where this important change can be pursued. Similarly, in my conceptual, practical, and artistic approaches to listening technologies, I like to experiment with technologies as tools rather than imposing one perspective, to question our certainties and open up to a multiplicity of other worldviews and listening positionalities. Many artists share this pursuit, including a growing number who are specifically interested in the sounds of trees—for example, Julia Adzuki, Jez riley French and Lau Nau, Alex Metcalf, Giorgio Magnanensi, Julie Andreyev, and Liz K. Miller.

Let us get back on the Arboretum's ground. Or rather, below. Another immediate lesson from listening to that eastern white pine is the realization of the stunning scale of a tree itself: its immense, invisible presence under the ground, an element in a vast network of life whose entirety will always evade any kind of perceptual and technological capture. Through that kind of relational hearing, my always only partial comprehension of trees has transformed and keeps transforming. Once identifying them as vertical elements of our shared environments—an impression imposed by our sense of vision—today, I cannot but approach them as vastly horizontal beings.

Another immediate lesson from listening to that eastern white pine is the realization of the stunning scale of a tree itself.

This, in turn, informs my visual perception. Senses are interconnected. They feed each other. Hearing—and by this term I don't mean reception of acoustic signals only, but also vibratory ones–can help us see and imagine the world around as from a different perspective, as "temporary aggregations of relationships," as biologist David George Haskell puts it in his 2017 book, *The Songs of Trees*.

In the scientific domain, investigations by ecologist Monica Gagliano and others suggest that the roots of trees and other plants have the ability to detect water sources by sensing vibrations produced by water movements in subterranean structures like pipes, even in the absence of moisture. Obviously, that sensing capacity is far from how we commonly understand "listening"—namely, as the reception of airborne waves. Nevertheless, this intricate technique of sensing vibrations of the surrounding world and responding accordingly might aid us in expanding not only our understanding of the trees as living, sensitive entities, but also the very notion of listening, as I have written elsewhere. Similarly, we have recently been learning that plants emit ultrasonic sounds, such as short rapid bursts when exposed to harsh conditions, as recently documented by plant scientist Khait Itzhak and colleagues in the journal, *Cell*. Researchers are still not sure about those signals, whether they are merely byproducts from a disruption in the transfer of liquids in their tissue or there is something more to them.

While Western scholarship has only recently begun to grant hearing to trees and other forms of vegetation, some indigenous epistemologies have developed and cultivated such knowledge for millennia. For example, Robin Wall Kimmerer, environmental and forest biologist and member of Potawatomi Nation, writing in *The Mind of Plants: Narratives of Vegetal Intelligence* (2021), reminds us that "(t)he Indigenous story tradition speaks of a past in which all beings spoke the same language and life lessons flowed among species. But we have forgotten—or been made to forget—how to

listen so that all we hear is sound, emptied of its meaning."

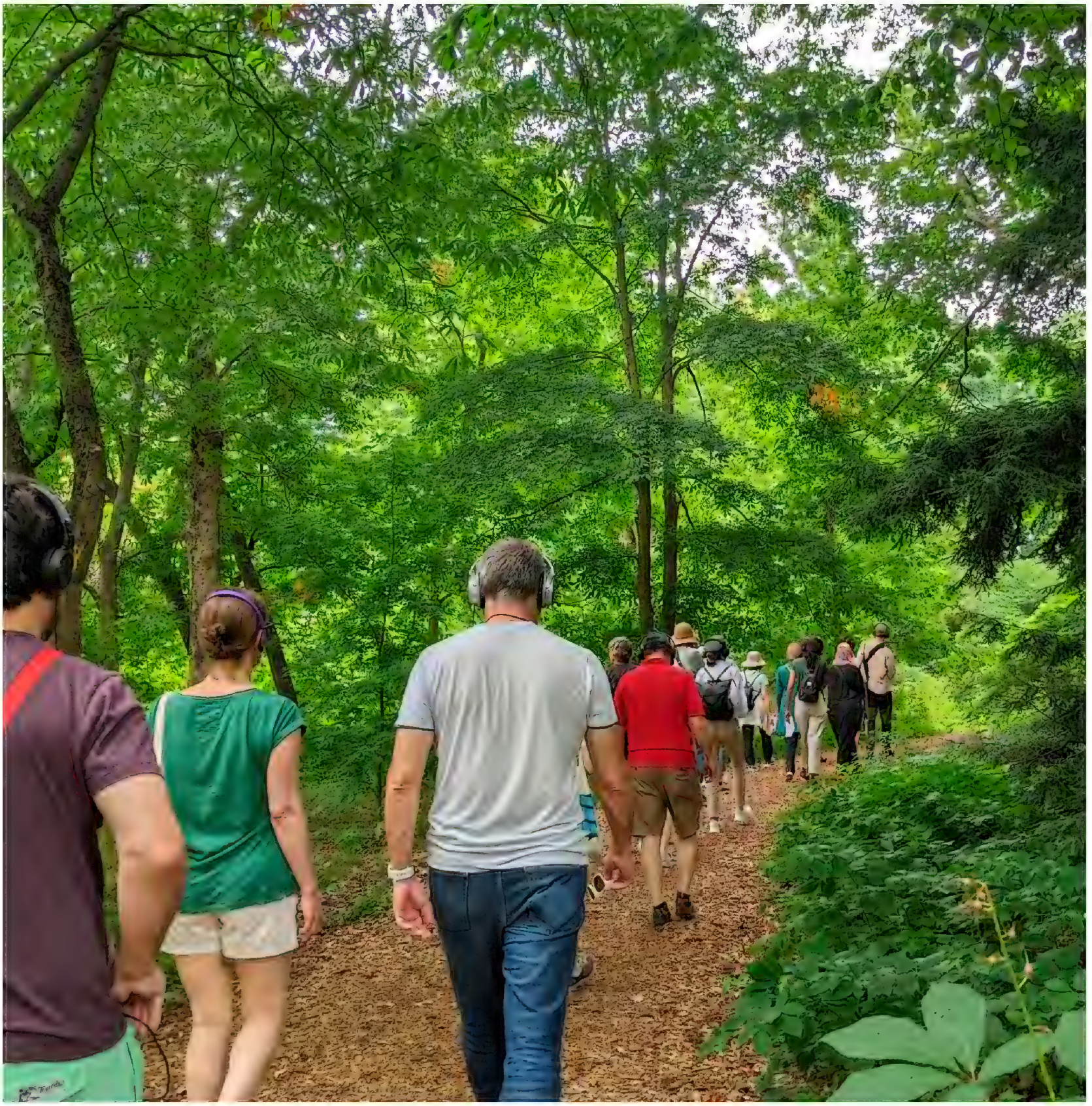
My visit to the Arboretum was one in a series of field recording sessions and soundwalks from 2022 to 2024. The 2023 soundwalk series was titled "Arboreal Sonorities," while the 2024 series was named "Nature Amplified: The Secret Sounds of Trees." While two of the soundwalks in 2023 were open to the general audience, one was specifically tailored for visually impaired and blind individuals. Soundwalking is a practice that involves traversing a space with a primary focus on listening. This practice emerged as a method for investigating the state of local and global soundscapes through the research of the World Soundscape Project (WSP). Established in the 1960s by Canadian composer R. Murray Schafer, the WSP comprised scholars, environmentalists, and artists dedicated to redirecting people's attention from landscapes to soundscapes as they became subject to the increasing intensity of noise from the industrial transformations of our lived environments. In her foundational essay "Soundwalking" (1974), group member Hildegard Westerkamp defined a soundwalk as "any excursion whose main purpose is listening to the environment. It is an exploration of our ear/environment relationship, unmediated by microphones, headphones, and recording equipment. It is an exploration of what the 'naked ear' hears and how we relate and react to it."

In my approach to soundwalking, however, I work with an array of sound technologies mentioned earlier. I use them cautiously, not to represent the world or to gain an accurate picture of otherwise imperceptible realms, but rather to open up listeners' imaginations to these hidden realms and temporalities. My aim is to hint at their existence and raise awareness, which, hopefully, may lead to tangible expressions of respect, appreciation, and care for them. During our soundwalks in the Arboretum, participants were provided with specialized receivers and headphones through which I transmitted previously recorded sounds. In addition to the sounds of trees from the Arboretum, I integrated soundscapes from other locations I had explored in recent years during my postdoctoral research, such as the Pacific rain forests and the hammocks at Canaveral National Seashore.

Forest soundscapes vary depending on factors like the types of trees, the species they host, and the micro-climate they foster.

We began our walk at the Hunnewell Visitor Center, making our way towards the marsh near the dawn redwoods. As we walked, we listened to an evolving soundscape that started with the immediate sounds of the marsh, accompanied by a previously recorded dawn chorus dominated by the recently returned red-winged blackbirds. As we moved further from the marsh, I began to incorporate recordings of dawn choruses from different geographical locations. These included a forest in Lidingö, Sweden, featuring a blend of larches, oaks, pines, and birches, providing a lush nesting ground for tits, finches, blackbirds, robins, nuthatches, and woodpeckers. We also ventured into a rainforest in Vancouver, home to hermit thrushes, robins, wrens, warblers, and barred owls, among other species. Forest soundscapes vary depending on factors

Jacek Smolicki is a Stockholm-based cross-disciplinary artist, designer, researcher and educator. His work explores temporal, existential, and technological dimensions of listening, recording, and archiving practices in human and more-than-human realms.



The author leads soundwalk participants past bottlebrush buckeye in the Arboretum, mixing the sounds of other trees and landscapes into their experience. *Photograph courtesy of the author*

like the types of trees, the species they host, and the micro-climate they foster. Thus, in addition to learning about the bird species characteristic of a given forest environment, careful listening to birds can offer insights into other intricate aspects of the forest, including its age and condition, often marked by the activities of woodpeckers.

Exiting the marsh, we navigated the denser part of the Arboretum. Here, I began mixing in sounds of rain and storms captured in the Arboretum and other locations. Depending on the type of forest, raindrops sonically activate their multiple components in diverse ways, with varying intensities and rhythms. Therefore, to a trained ear, familiar with the differences between the types of vegetation in specific forests, the sound of rain reveals a multitude of species and the relationships between them that constitute the forest's ecosystem. Exposed to sudden storms and heavy rainfalls, with directions radically altered by unexpected wind gusts and hurricanes, the dry palm leaves and their fallen boots in Canaveral Seashore's hammocks create a highly particular sonic signature, unique to that part of the world. Similarly, ancient rainforests in the Pacific Northwest, with their abundance of hollow tree trunks and nursing logs adding to the already thick foliage, resonate in a way that is highly distinguishable from the sound of rain in, for example, a pine-dominated forest in central Sweden. As we walked, we listened to these different instances of rain and storms in forests from various perspectives, some enabled by my work attaching contact microphones to tree trunks and branches to gain a better insight into the variety of sonic effects—percussive shots, extended squeaks, resonances—from within, inside-out.

The sound of rain reveals a multitude of species and the relationships between them that constitute the forest's ecosystem.

After emerging from this augmented experience of rain in the forest, I shared with the participants a range of subtle and intimate sounds generated within different parts and layers of the trees' bodies, including the hybrid yew, eastern white pines, and white and Siberian elms. I was particularly keen to share a recording of the root system of a Siberian elm I made in July 2024. Siberian elms are known for their massive roots that span wide patches of land, occasionally popping to the surface here and there. On one of my field study walks, I encountered one with an exposed root that hosted several cavities filled with small pools of rainwater. After gently submerging my hydrophones and attaching geophones, I was soon invited into an intricate soundscape. It was dominated by a continuous series of pops and clicks as the water was soaking into the root's tissue. This surprisingly loud, staccato-like pattern was accompanied by much more irregular, high-pitched noises and rustles made by insect larvae submerged in the muddy layers of these tiny pools. Besides those sounds, the root system transmitted vibrations from the upper part of the tree, including those caused by the wind brushing the tree crown and even cicadas persistently calling their mates. Predictably, this unique soundscape was persistently disturbed by car and air-traffic noises amplified by the large volume of the tree and its enormous root system.

As we walked further, I invited participants to touch the bark of the trees and experiment with the various sonic effects resulting from these interactions. By affixing contact microphones to the surface of a cork tree, we delved into the rich sounds produced by our contact with its exceptionally thick yet resonant bark.

We continued by tuning into the inner soundscapes of fallen tree logs and stumps, orchestrated by, for instance, by beetle larvae residing within and wasps attempting to establish their nests in numerous holes, many of which appeared to be the work of woodpeckers. As we progressed, we passed by a small marsh where the roots of highbush blueberries were submerged, surrounded by an array of aquatic plants. Using hydrophones, we captured and listened to the subtle pops of photosynthesis. Our journey concluded at one of the three ponds at the junction of Meadow, Bussey Hill, and Forest Hills Roads. While listening in real time to an array of underwater chirps and squeaks generated by numerous

aquatic insects, possibly dragonfly larvae, along with sounds and vocalizations of bullfrogs and small fish, I gradually mixed in hydrophone recordings from my visit to Mosquito Lagoon in Florida. This environment is known for its rich variety of species, supported by an intricate network of mangroves—a unique type of coastal vegetation made up of salt-tolerant trees and shrubs partly submerged in water. The sounds we listened to came from a continuous field recording I made there in March 2023, which included shrimp, oyster toadfish, bluck drum, cricket frogs, bottlenose dolphins, and manatees.

As mentioned earlier, the way sound propagates and how we experience it encompass more than just an acoustic, airborne phenomenon. It always concerns vibration. Such vibrational qualities hold particular significance for visually impaired individuals, whose sensitivity to both sonic and tactile stimuli is often highly refined. The version of the soundwalk tailored for visually impaired participants emphasized these aspects. While visually impaired people use listening daily to extract cues from the environment for safe navigation, the soundwalk presented an opportunity to explore listening from a different perspective and with a different intention. The potential risk was that by redirecting attention to these other, typically imperceptible auditory registers, their sense of navigation might become disoriented. Navigating between the amalgam of immediate and distant, prerecorded soundscapes was indeed challenging but, as participants reflected, highly rewarding.

It's important to emphasize that the soundwalks designed for the Arboretum were not meant to be ends in themselves. Instead, I saw them as invitations to engage in listening to the surrounding world on a daily basis— encouragement to ponder not only what we focus on when we listen to the world around us, but also how we listen.

As I soundwalked the paths of the Arboretum, using either my microphones or my "unarmed" senses, I kept reflecting on how much of what we hear there daily doesn't speak for what we encounter, namely the rich collection of trees, plants and animals. The soundscape of the Arboretum is excessively dominated by anthropogenic sounds, particularly the noise of car traffic that envelops the entire area. The proximity of the hospital adds to the soundscape's contamination with loud sirens, and many routes of dense air traffic cross the sky directly above the site. Almost every recording I made in the Arboretum during my fieldwork, including the gentlest rustles of water making its way through the root systems, has a disturbing imprint of traffic noise. Some of this noise comes from vehicles used within the Arboretum itself.

I kept reflecting on how much of what we hear there daily doesn't speak for what we encounter, namely the rich collection of trees.

Given this omnipresence of anthropogenic noises surrounding the arboretum, changing the overall sonic experience might not be possible. It is after all a garden, and human activity is as much a part of its soundscape as the chatter of underwater insects. Against this pervasive and inescapable realm of human-generated noise that inevitably pervades the site, soundwalks can offer a reminder that beyond the thick layer of our noisy urban fabric lies a rich realm of nature's activities, whose sonic imprints are much less invasive and obtrusive, if perceptible at all. If we pay attention, there is much to learn from these hidden realms.

IN REVIEW

LANDSCAPES OF RETREAT

BY ROSETTA S. ELKIN (K. VERLAG, 2022)

Reviewed by Geoff Manaugh

The events are now too common to be considered a sign of things to come. Million-dollar homes washed into the sea, as the beach around them churns with winter storm waves. Entire villages thrown off-kilter, the permafrost beneath them melting askew. New York City families drowning in basement apartments as flash floods of motor-oil runoff, trash, and animal feces roar in from the street. These are not scenes from the future.

Landscapes of Retreat by Rosetta S. Elkin, founding associate professor of the landscape architecture program at the Pratt Institute in Brooklyn, asks why humans have come to believe that they can inhabit certain landscapes in the first place. (Published in a sumptuous limited-edition paperback by K. Verlag in 2022, the book is also available as a website, at http:/landscapesofretreat.com). Is it now time, Elkin asks, to leave some places behind altogether, moving away—that is, retreating—from sites unfit for long-term settlement? Glossy real estate brochures tout new developments on recently formed coastal sandbars or deep inside the tinderboxes of badly managed forests—but beautiful photographs and picturesque views misrepresent what is really at stake in considering these places habitable.

Elkin understands that suggesting humans have limits, let alone that we should voluntarily abandon our lifestyles

Illustration by Celyn Brazier

and family homes, can be controversial. She thus wants to ensure that her terminology is clearly defined. The very term retreat is fraught because it suggests a lack of agency, Elkin writes. It implies a humiliating response forced upon us by negative circumstance, not a positive destiny we have chosen for ourselves. Retreat, however, should not be mistaken for mere displacement or involuntary exile; retreat can be thoughtful and deliberate, even therapeutic. "Retreat," she writes, "is not leaving in defeat, nor is it giving up hope"; rather, it is a "collective decision to resettle away from risk and vulnerability" (10). Retreat can be "reparative," not just for the precarious landscapes we leave behind, but for our own well-being, repairing ourselves by establishing home elsewhere, in a place that can actually sustain us. Retreat is thus recast as an intentional act of de-escalation: we step back from the world in order to improve it.

To show how this rehabilitative version of retreat can be achieved, Elkin lays out an ambitious agenda, organized into five chapters, each documenting a specific site where people are faced the realization that to survive requires departure. Throughout the book, Elkin explores examples of planned retreat and rewilding in Japan, Chile, Alaska, Nepal, and Québec. This gives her project the feel of a travelogue, as readers hike along with her into misty pine forests on the Kyushu coast, along melting permafrost in the village of Niugtaq, or up into remote mountain villages in the Himalayas. The approach not only works, but pays dividends. It is precisely the character and grain of these locations, the particular hopes and personal worries of the people who live there—not to mention the sounds of streams flowing over fresh rockfall, or the suck of coastal mud as high tides reach ever-further inland—that make the abstract question of retreat so material. The world is changing, and Elkin shows us where human settlement practices are struggling to keep pace.

The opening chapter is arguably the book's most interesting, as it explores

"One place to look for the landscape of retreat is in the pre-history of concrete, in a time when the temporality of plant life was cherished as a legacy."
—Elkin, p.35

centuries-old landscape practices in Nijinomatsubara, Japan, that still remain viable today—primarily the cultivated "coastal protection forest" whose trees, Elkin writes, "were planted to grow old rather than produce timber." Intended to be sustained from generation to generation as a physical barrier against typhoons, tsunamis, storm surges, and other coastal dangers, including landslides and erosion, the forest at Nijinomatsubara is an example of soft infrastructure in invigorating contrast to today's obsession with hardscape. Prior to 17th century settlements, trees were planted to anchor riverine silt and sandy ground and a habitat for nonhuman species. "The case of Nijinomatsubara," Elkin provocatively writes, "suggests that one place to look for the landscape of retreat is in the pre-history of concrete, in a time when the temporality of plant life was cherished as a legacy for future generations" (35). Indeed, it is not just the pre-history of concrete, but pre-modern solutions altogether that present intriguing possibilities for guiding 21st-century retreat. Humans have retreated before, and Elkin wants to know how they did it.

These older indications that the danger of a particular landscape or setting had been known for centuries brought to mind a 2016 Masters of Landscape Architecture thesis project by Elise Hunchuck at the University of Toronto. Called *An Incomplete Atlas of Stones*, Hunchuck's work explored the warning signs—alternatively known as "lesson stones"—carved centuries ago and placed along the Japanese coast to warn future generations about the perils of living too close to the sea. They are monuments of an earlier retreat. "Do not build your homes below this point!" one warned. The stones, of course, are now located well above present-day communities, which, by definition, thus stand in clearly-marked zones of mortal danger, flagged by concerned residents and victims of previous disasters hundreds of years ago. It is we, anomalous modern humans, who have decided that we are clever enough to construct homes and freeways there.

Elkin's book cites many other types of landscape unfit for inhabitation, including what she calls "vulnerable or young land formations" (21), such as sandbars, newly thawed permafrost, and recently deposited sediment fields. Decades of hubristic amnesia—not to mention recklessly optimistic home insurance policies and government bail-outs for affected homeowners—have inspired entire cities to take root in landscapes that were already serving a vital, but overlooked, purpose. These other roles for landscapes, such as absorbing seasonal flooding to recharge local aquifers, are more vital than ever now, but their lack of cultivation, through modern eyes, paradoxically looks wasteful. That this might require a new system of accounting, one that assesses land not for its agricultural potential but for its protective, rehabilitative qualities, is something Elkin describes without necessarily going into financial detail. Does this require government intervention? International land trusts? Private philanthropy? These are wonkish but vital questions. Central to the ideology of retreat is learning how to utilize these sites anew, as flood barriers, wildlife corridors, breeding habitat, and carbon sinks, but it is notoriously difficult to assign a specific dollar value to these other uses. The time horizons of capital and human memory are very different than the atmospheric life cycle of carbon or deep-ocean chemistry.

To address this, part of the book's analysis is economic. As the insurance industry reels from badly wagered bets on homes in places such as Florida's hurricane-prone coastal regions or California's wildfire-wracked mountain forests, finance has played a key role in fostering negative behaviors from which we now must step back. Elkin insists that we have been asking the wrong questions after disasters, not the least of which "was *how* to build back, not *whether or not* to rebuild" (16, emphasis in original). Insurance exists as a false promise that now is the time to put our roots back down into recently disturbed soil, to reestablish our claim over ephemeral, changing lands, and to sleep, once again, upon terrain we have never respected. We not only need a new temporal framework through which to understand the task of human settlement; we also need a new kind of accounting for the true risks and expenditures involved.

This suggestion—that humans are encountering and settling on landscapes we don't fully understand, because, the land is too young to be legible—is made most strongly in her chapter in Nepal. There, Elkin visits what she calls "land [that] is not timeworn and stable; it is young and unsteady" (190). What she describes is a conflict between geological time frames and human ones; to the modern reader, the Himalayas surely seem as ancient as the world itself, but they are still rising and eroding, ceaselessly dynamic, prone to enormous earthquakes and the resulting avalanches that routinely wipe out villages, creating new landscapes unfit for settlement.

Even transient landforms, such as rockfalls, can be misinterpreted as stable ground, a welcoming foundation for a building or town. To remedy this, Elkin emphasizes the importance of engaging with the timelines and worldviews of indigenous communities—in the Himalayas, the Canadian North, and rural South America—to help widen our historical and ethnographic perspective on where humans can settle (and how). Elkin foregrounds other approaches to landscape research, including a short essay by landscape architect John Koepke, framing a facsimile of the US/Russia land treaty that made Alaska part of the United States, a brief interview with Chilean eco-activist Bernardo Reyes, and sketches of fungus growth in Japan's Nijinomatsubara Forest. Because retreat has effects at all scales, Elkin also takes a diversion into the world of benevolent microorganisms, documenting, through text and sketches, the growth of fungus during the time she spent in Japan's Nijinomatsubara Forest.

Through this rhythm of original reportage, archival visual materials, and standalone interviews, the book establishes a solid framework for its own continuation, beyond the locations Elkin focuses on. As

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Landscapes of Retreat concluded, I found myself wondering what Elkin might have seen in Miami Beach, which has been raising many of its streets to help mitigate seasonal flooding; or in Jakarta, an entire metropolis that has sunk more than a foot in twenty years, inspiring the Indonesian government to fund the construction of a brand-new capital city, on a different island, more than 600 miles away.

In other words, the entire world is becoming a landscape of retreat. Elkin has found five timely sites worthy of our attention, but they are perhaps most useful when seen as rousing first scenes in a rapidly expanding story. It is pessimistic but not unrealistic to suggest that all towns and cities within vertical reach of the sea will need to be relocated or that entire regions of the world, including the American Southwest, will need to be at least partially abandoned due to drought, asphyxiating heatwaves, and wildfires. Retreat will very likely become the dominant logic of human migration and renewal—even for those of us not yet convinced of its necessity or its benefits.

Retreat will very likely become the dominant logic of human migration and renewal.

Elkin's deliberate use of reparative, therapeutic language sometimes bumps up against the harder reality of how that retreat will be physically realized and implemented. In her chapter on Canada's Gaspésie Peninsula, she writes about the challenge and cost of "unbuilding" our towns and cities as a necessary act of environmental stewardship. "Unbuilding," Elkin writes, "refers to the removal of foundations, septic tanks, driveways, and the partial structures themselves" (265), such as abandoned homes or municipal buildings, clearing the land again for post-human rejuvenation. These are questions of labor, affordability, and political enforcement, requiring folks to clean up their mess before moving out, but the book understates the difficulty of this task.

If we must abandon South Florida to the rising sea, who will collect all the rusting cans of paint sitting in people's garages; who will retrieve the pesticides and detergents hiding in kitchen cabinets; who will safely dispose of the hazardous materials from industrial sites throughout the state? What will we do about the nonhuman species who also live there because of humans, who have tagged alongside us, living off of our discarded food or drinking from dishes of clean water we put out for them? We are not the only beings who will be affected by mass human retreat, and the residue of our inhabitation could very well prove worse for other creatures as our now-empty suburbs flood, as our abandoned towns go up in unchecked flames, sending household plastics—and worse—out into a world we think we've distanced ourselves from. Done hastily, retreat risks becoming yet another stopgap, as people flee damaged landscapes they once called home, handing the most difficult problems of site remediation and permanent clean-up to other species and future generations.

Elkin likely would agree with the words of Britt Huff, the mayor of Rolling Hills, a tony development south of Los Angeles, known for its enormous houses, private tennis courts, and countless swimming pools—and, now, slow landslides. As an entire street of homes slid downhill in the autumn of 2023, reactivated by a long winter of fierce storms and record rainfall, Mayor Huff was asked what might come next, not just for Rolling Hills but for the homeowners who were being forced to evacuate. "This remains an active situation," he told the Los Angeles Times.

Mercy

Staci Halt

on the brink of extinction
golden-winged warblers who prefer
a thicket exposed to open
sky over any other habitat

rallied some years ago

when a blight brought down nearly
every last chestnut tree
spanning the country

the tiny bird's population
soared
as whole forests were devastated

is it true that in all of us,
the violence of thriving means
something else rots

means life is a zero sum
game means a creature
beneath

our notice chirps to
its hatchlings

and flits its yellow self
against the morning's cobalt
backdrop simply

because millions of shady giants
succumbed and moved
out of the way

STACI HALT *teaches and writes near Boston, and parents six awesome humans and four cats. Her work has previously appeared or is forthcoming in* Rattle, Salamander Magazine, Southern Humanities Review, The Los Angeles Review, *and others.*

Winterizing Roses

By Rachel Lawlor,
Arboretum Horticulturist

Every fall, depending on weather conditions in mid-to-late November, the cultivated roses found in the Bradley Rosaceous Collection (BRC) must be put to bed for the winter. Many cultivated roses are less hardy here, or are grafted onto rootstock, requiring some extra care to flourish again next season. We start by pruning each rose—removing dead, old, or less vigorous canes, crossers and crowders, and late season growth that will not harden off in time for frost. Usually, I prune the remaining canes to a height around 3 feet, using my mid-thigh as an informal marker. I make cuts above plump, healthy, outward-facing buds to ensure stems are strong enough to support next year's flowers, while encouraging growth away from the center, thus allowing more airflow through the shrubs. Any leaves or debris that could harbor disease for next year are also removed. Once all the roses have been pruned in this manner, shaping them for next year, they are then hilled up with mulch around the bases to protect the crown of the shrub and the graft union, if present. This will insulate the plant from the cold and reduce winter dieback significantly. Once the risk of a hard freeze has passed in the spring, the excess mulch will be spread about the bed, and any dieback that did occur will be removed.

Photograph by Rachel Lawlor

167
Plants winterized

48
Rose cultivars in the BRC

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